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"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 51 JULY 1965 NUMBER 3

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A SUMMARY OF BAND RETURNS FROM LESSER SNOW GEESE (*CHEN HYPERBOREA*) OF THE PACIFIC FLYWAY[1]

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Population distribution and mortality rates were determined for the lesser snow goose population wintering in the Central Valley of California. Data were from geese banded from 1952 through 1963. The southward migration of snow geese into the Tule Lake area occurs along two distinct migration routes—one through Alaska, and the other through the Northwest Territories and Alberta. After a short period at Tule Lake they continue their migration south to the wintering grounds. Approximately one-half of the snow goose kill on the Pacific Flyway takes place in the Sacramento Valley. The average annual snow goose population turnover is 38.1 percent, with 28.7 percent taking place during the hunting season. Minor changes in hunting regulations would have little effect on the number of snow geese taken by hunters.

INTRODUCTION

A basic step in waterfowl management is to determine the yearly population-turnover of a species. The proportion of this turnover that can be taken by hunting without future harm to the population can then be determined. A portion of any waterfowl population is lost each year to natural causes, so the ultimate aim of management is to manipulate the population to substitute hunting mortality for the largest possible proportion of the annual loss. When sufficient banding data become available for analysis this goal may become a reality.

From 1952 through 1963, the Pittman-Robertson Waterfowl Research Project 30-R, California Department of Fish and Game, banded 14,888 lesser snow geese. Of these, 13,916 were banded on the Tule Lake National Wildlife Refuge in Siskiyou County near the Oregon border, and 972 were banded on Sacramento National Wildlife Refuge near the town of Willows. All of the geese were captured with cannon net traps.

Tule Lake is a concentration point for lesser snow geese on their migration to and from the wintering grounds in the Central Valley of California. The banding program at Tule Lake has been continuous since 1952. Most of the goose banding was done during the hunting season, normally the last week of October and the first two weeks of November. This coincides with the usual fall population peak at Tule Lake, when approximately 125,000 snow geese are present. Post hunting season banding was conducted from the middle of March until the middle of April. Trapping success varied because the geese were not concentrated on the refuge by hunting.

All of the geese banded on the Sacramento National Wildlife Refuge were trapped during the inseason and postseason periods of 1953. Due

[1] Submitted for publication, February 1964. A contribution of Federal Aid in Wildlife Restoration Project 30-R, "Waterfowl Studies."

to the difficulty in trapping, no further attempt was made there by the project.

DISTRIBUTION AND MIGRATION

Since Tule Lake is in the southern part of the migration route, direct recoveries cannot be used to determine distribution of hunting pressure for the entire Pacific Flyway. Assumptions are made that banded geese spread evenly throughout the population, and that the rate of band recoveries was directly proportional to the hunting pressure. An analysis of the recoveries indicated that California hunters exerted the

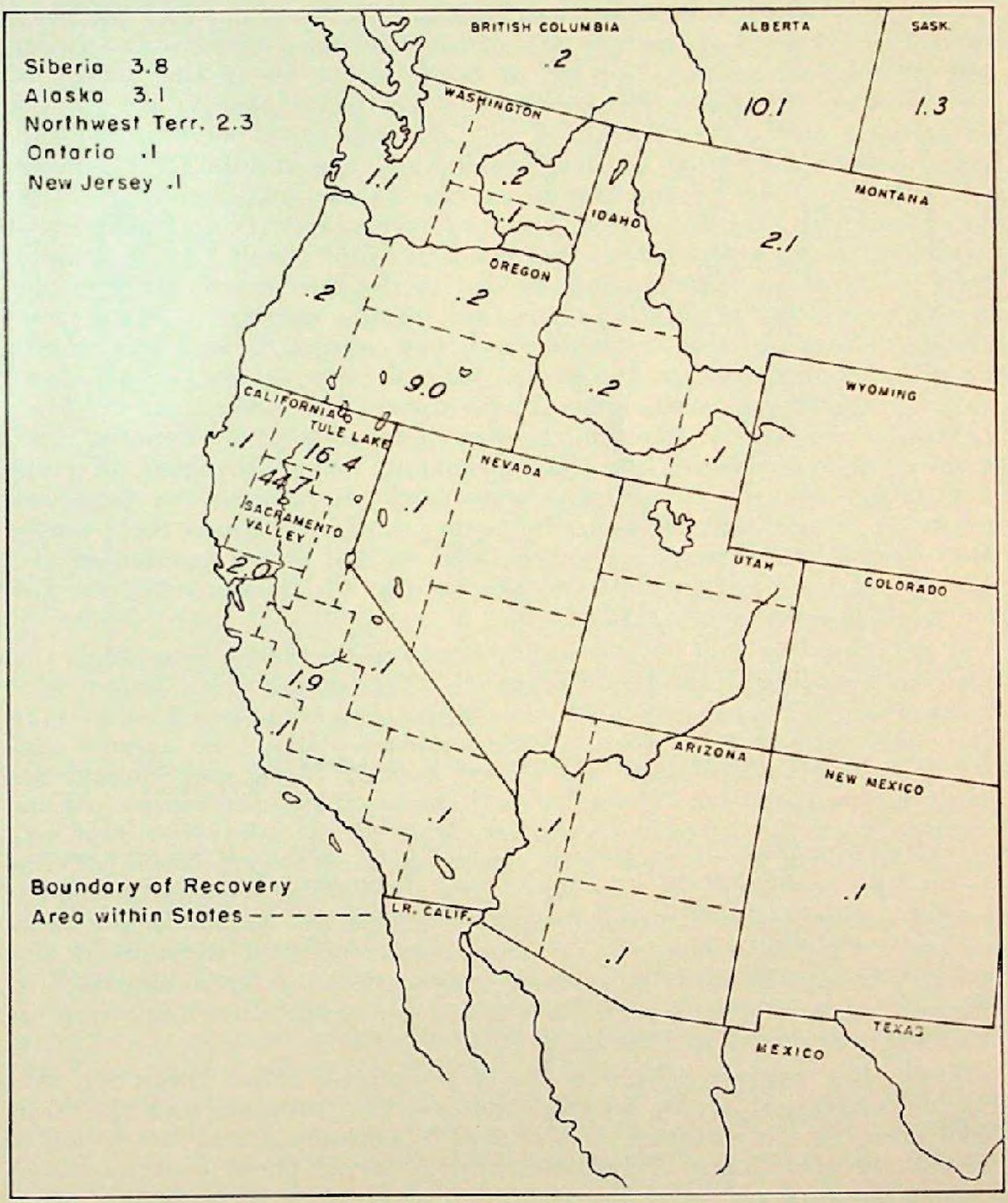

FIGURE 1. Kill distribution, by percentage, of 1,639 snow goose indirect band recoveries from geese banded at Tule Lake and in the Sacramento Valley, 1952–62.

greatest pressure on the lesser snow goose population. The largest number of band recoveries, 44.7 percent, came from the Sacramento Valley (Figure 1). Northeastern California, in the vicinity of Tule Lake, was second with 16.4 percent. During the first half of the study period, both Tule Lake and the Sacramento Valley had approximately the same number of band recoveries, but in the last few years there has been a noticeable decline in the band recovery rate from the Tule Lake area.

There was a daily increase in the number of band recoveries from Tule Lake up to November 15, and then a sharp decrease (Figure 2). The years in which there were split hunting seasons are included with the years in which the season was continuous. Since most of the geese had left by the end of the first half of the hunting season, this inclusion had little effect on the drop off of band recoveries in the middle of November at Tule Lake. The recoveries from Sacramento Valley showed an increase about the time the Tule Lake recoveries were decreasing. This increase continued until approximately the middle of December, and then dropped off for the remainder of the hunting season. The sharp build up and drop off of band recoveries from Tule Lake can be attributed to several factors. The gradual build up of the population until the peak was reached coincided with the recovery of bands. Also, as the waterfowl population increased on the portion of the refuge closed to hunting, the available food was consumed, and more birds sought additional food on the surrounding farmlands. By the middle of November, adverse weather conditions usually prevailed, and with an increasing shortage of food and continued harassment by hunters, most of the geese moved south into the Sacramento Valley. However, in years of good grain crops and smaller waterfowl populations, the food was not in short supply at the time the geese usually continued their southward migration. Instead, they remained on the closed portion of the refuge and were not available to the hunter, which accounted for the decreased band recovery rate.

It is interesting that 3.8 percent of the band recoveries came from the Siberian breeding grounds. Just how this rate of recovery compares to those of North America is unknown. When comparing one area such as Tule Lake with another (e.g., the Sacramento Valley) we assume that the percentage of hunters who shoot banded birds and return the bands is essentially the same for both areas. This assumption cannot be made with the Russian recoveries. Most of the recoveries reported by the Russians were obtained by shooting on Wrangel Island off the north coast of Siberia during May, June, and July. Russian biologists started a snow goose banding program on Wrangel Island in the summer of 1960. Their bands have since been recovered throughout the Pacific Flyway. Eventually, enough information should be available to estimate what proportion of the snow goose population wintering in California originates in Siberia.

In further analysis (Figure 1), it is apparent that there are two distinct migration routes between the breeding grounds and the Tule Lake area. One is through Alaska and Washington, and the other is through the Northwest Territories and Alberta. These routes became evident in the spring of 1956, when 430 snow geese were marked with colored dye at Tule Lake (Kozlik, Miller, and Rienecker, 1959). The

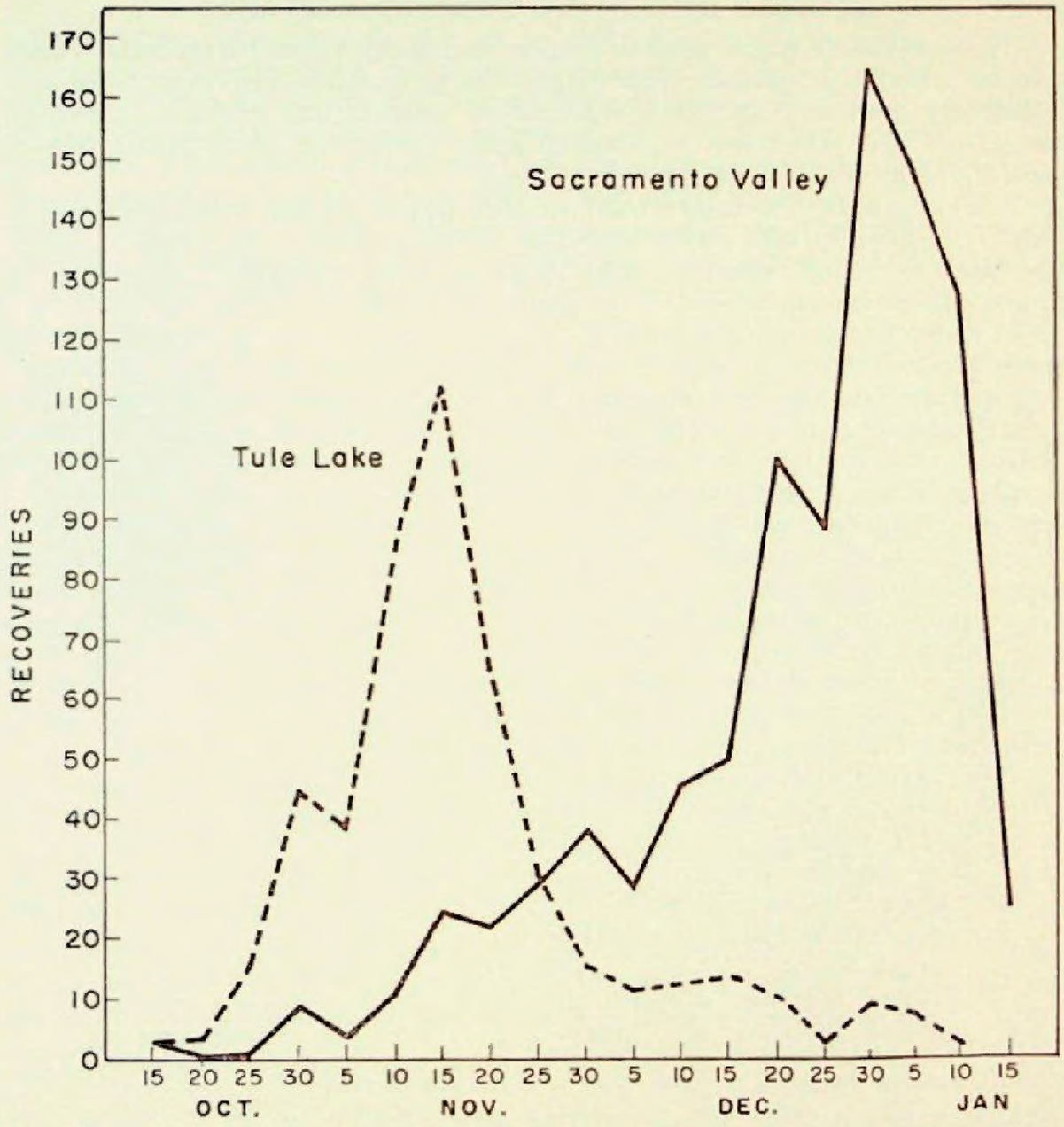

FIGURE 2. Frequency distribution of band recoveries from Tule Lake and the Sacramento Valley, 1952–63.

proportion of the geese using the two routes is not known, but the majority seem to come through the Alberta-Northwest Territories. From Tule Lake, the geese continue south to terminate their migration on the wintering grounds of the Sacramento and San Joaquin valleys.

Other than a few strays, there is little deviation from the migration routes. The migration route of the cackling goose (*Branta canadensis minima*) is very restricted, showing less deviation than we found for the snow goose (Nelson and Hansen, 1959).

Only two snow goose band recoveries, out of 2,459, came from Imperial Valley, although an average population of 10,000 was wintering there. This group probably migrates through Montana, Utah, Nevada, and Arizona into the Imperial Valley, missing the northern part of California.

METHODS USED IN CALCULATING MORTALITY

Hickey (1952) states that life table mortality rates for specific years are of extremely limited reliability. It is only when recovery rates are relatively constant, as when a series of cohorts are grouped together in a life table, that we can expect approximations of mortality rates actually occurring in wild populations.

The composite life table, used in this paper, is the most frequently employed type in bird investigations (Farner, 1955). It involves treating the records of individuals hatched in different breeding seasons as though they were members of the same year-class.

In order to use band recovery data obtained the same year the geese were banded, it was necessary to compensate for the fact that the banding was done in the hunting season rather than prior to the season. An additional column has been added to the life tables to show the correction made for inseason banding (Tables 1, 2, 3, 5, and 6). The tables are basically the same as those devised by Bellrose and Chase (1950) except for a modification of the formula to correct for inseason banding. A mean date of banding activities for the year is established by finding the median bird that was banded. The date on which this median bird was banded is the mean date of banding activities. The assumption is made that all birds were banded on this date.

Band recovery data must be available for the year prior to the year studied so that second-year recoveries of the prior year can be used to determine the spread of the kill during the hunting season of the year studied. Additional years prior to the second year can be included to increase the sample size. Only recoveries from the banding station south to the wintering ground were used. The purpose of the formula is to determine the number of band recoveries prior to the mean date of banding activities that would normally occur had preseason banding taken place. The formula is as follows:

$$\frac{\text{Recoveries from present year before mean date of banding}}{\text{Recoveries from prior year before mean date of banding in present year}} = \frac{\text{Recoveries after mean date of banding in present year}}{\text{Recoveries from prior year after mean date of banding in present year}}$$

Data in the following equation were derived from recoveries of immature snow geese banded in 1955. The mean date of banding activities was November 5.

$$\frac{X}{4} = \frac{39}{67} \qquad 67X = 156 \qquad X = 2.3$$

The 2.3 band recoveries, those from the start of the hunting season until the mean date of banding activities, are added to the 39 bands recovered after the mean date of banding activities. The 41.3 band recoveries are direct recoveries and are equivalent to those of preseason banded adult birds.

Other waterfowl mortality studies show that immature birds are much more vulnerable to hunting than adults. The lesser snow goose is no exception. This is obvious when comparing the direct band recoveries of the immature with those of the adult (Tables 1, 2, and 3). The immature snow goose is more vulnerable at the beginning of the hunting season than the adult (Table 4). When correcting for inseason

banding, the difference in the adult and immature kill ratios must be taken into consideration. This can be accomplished by multiplying the immature segment of the kill ratio which occurs prior to the mean date of banding activities by the number of adult band recoveries between the start of the hunting season and the mean date of banding activities. As an example, up to November 5, the adult-immature kill ratio is 1:1.6 (Table 4). The 2.3 band recoveries prior to the mean date of banding activities (as previously derived) multiplied by 1.6 gives us 3.7 as the corrected immature kill.

MORTALITY

The tables are not presented with the idea they are the final word on snow goose mortality, but they do contain what information has been learned to date.

Tables 1, 2, 3, and 5 show return data from 10,304 lesser snow geese banded during the 1953 through 1963 hunting seasons on Tule Lake National Wildlife Refuge. The 11th year band recoveries are not necessarily the completion of a band recovery cycle, but are a limitation on band recovery data at the time of this writing. Probably the band recovery cycle will extend for several years before it is completed. The cycle for the snow goose is very similar to that found for the cackling goose by Nelson and Hansen (1959).

Data on 4,296 snow geese banded as unsexed immatures (Table 1) indicate a first year mortality of 49.1 percent, a rate twice as great as for adults (Tables 2 and 3). There is a slight difference between the mortality rates of the adult males and females. Table 2 shows a mortality rate of 22.5 percent for males, compared to 25.0 percent for females (Table 3). A difference of 2.5 percent can be of little significance when comparing mortality rates in life tables. However, field studies indicated females are more vulnerable to predation during the nesting season. Therefore, it is conceivable the female mortality rate would be higher than the male rate, assuming hunting pressure is the same for both sexes. The sex ratio of trapped adults indicated that males predominated by 2 percent, which implied the female had a higher mortality than the male.

Immatures and adults were combined in Table 5, the results indicating an average annual population turnover of 35.4 percent. According to Bellrose and Chase (1950), life tables with sex and age groups lumped are not representative of the population involved, due to the selectivity of the traps. This is possible when trapping ducks in stationary bait traps, but is not necessarily true when trapping by cannon nets. Boyd (1956) states that one of the important features of the cannon net technique is that when the net is concealed no trap response develops. Differential migration with respect to age and sex can be the cause of a biased sample, especially if the sample is obtained during the early part of the fall migration. The age ratio of the trapped geese compared closely with observations of the population at the time of trapping.

The waterfowl banding year starts on May 1 and ends April 30. Since postseason goose banding is conducted during March and April, few, if any, direct band recoveries would be expected. Table 6 indicates 5

recoveries out of 2,682 banded geese. Although the samples are smaller than those of inseason banding, the mortality rate is reasonably close to that of the adults in Tables 2 and 3.

According to Lauckhart (1956), if the band recovery data from preseason and postseason banding are taken from the same or similar waterfowl populations at the same banding station in identical years, and exposed to the same hunting pressure, then they could be used to determine hunting season loss. Table 7 summarizes snow goose mortality, derived by using Lauckhart's method. In computing the data for Table 7, the 1961 and 1962 inseason banding years were deleted so that the inseason banding years corresponded to the postseason banding years of 1953 through 1960. This deletion is the cause of the discrepancy between the first year mortality of Table 7 and that of Tables 1, 2, 3, and 5. The annual population turnover is 38.1 percent, with 28.7 percent occurring during the hunting season. This leaves 9.4 percent mortality from natural causes for the remainder of the year.

In applying this method to the immature goose mortality of 54.6 percent, we find that 46.4 percent comes during the hunting season, and 8.2 percent during the remainder of the year. The higher natural loss found for adult females as compared to adult males (Table 7) would normally be expected. However, the data indicate that hunting loss for females is only half as great as that for males. It is assumed that hunting pressure should be approximately equal for both sexes. Since the sexes are alike in coloration and have only a slight difference in weight, it is unlikely that hunters could select males in preference to females. A slight differential migration that occurs between the sexes could affect hunting mortality, but not to the extent indicated in Table 7. These assumptions plus the fact that the percentage of direct band recoveries is practically the same for both sexes leads me to question the validity of the data in Table 7.

The hunting season loss for combined sex- and age-groups (Table 7) is of questionable value. When applying the data in Table 7 to the snow geese of the Pacific Flyway, the average annual hunting season loss is approximately 50 percent more than that indicated by the United States Fish and Wildlife Service through their Waterfowl Hunter Mail Survey. Until additional data become available, Table 7 should not be regarded as more than a very rough estimate of hunting season loss.

We can conclude that the snow goose population is in good condition, since the population of the Pacific Flyway has been increasing the past few years. It is doubtful that any minor changes in length of hunting season will change the percentage of hunter kill to any great extent, unless the season were extended appreciably into January.

Doubling the bag size or decreasing it by half would have no material effect on the population. In reviewing the hunter bag-checks made in the vicinity of Tule Lake from 1953 to 1961 by personnel of the Tule Lake National Wildlife Refuge, one snow goose per hunter was average. This average is only for hunters or parties of hunters who had snow geese in their bag. Very rarely were hunters checked who had more than three snow geese. During the period, the daily bag and possession limit was six.

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I wish to express my appreciation to personnel of Project 30-R for assistance in the trapping and banding program, and in the tabulation of the data, especially A. W. Miller (now of the U.S. Soil Conservation Service) and Burton D. Collins who initiated the goose banding program at Tule Lake. Thanks are due also to Frank M. Kozlik for guidance in the preparation of this paper, to John E. Chattin for reviewing the manuscript, to personnel of the Tule Lake National Wildlife Refuge for cooperating with the program, and to Cliffa Corson for preparing the figures.

SUMMARY

Population distribution and mortality rates were determined from return data for 14,888 lesser snow geese banded at Tule Lake, and in the Sacramento Valley from 1952 through 1963.

The California hunter exerts the greatest hunting pressure on the population, 44.7 percent of the kill occurring in the Sacramento Valley, and 16.4 percent in the vicinity of Tule Lake.

Snow geese numbers build to a peak in the middle of November at Tule Lake, then due to adverse weather and in some years a shortage of feed, they continue their migration south to the wintering grounds in the Sacramento Valley.

There are two distinct migration routes between the breeding grounds and the Tule Lake area: one through Alaska and Washington, and the other through the Northwest Territories and Alberta.

The first year mortality rate for immature snow geese is 49.1 percent, compared to 22.5 percent for adult males and 25.0 percent for adult females. The average annual snow goose population turnover is 38.1 percent, with 28.7 percent of the loss taking place during the hunting season and 9.4 percent occurring during the remainder of the year.

It is doubtful if any minor changes in the length of hunting season or size of bag limit would affect the number of hunter kills to any great extent.

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TABLE 1

Life Table for 4,296 Immature Lesser Snow Geese Banded Inseason at Tule Lake, California

Banding year May 1-April 30	*Number banded*	*Direct uncorrected*	*Direct corrected **	*Number of bands returned*										
				2nd yr.	*3rd yr.*	*4th yr.*	*5th yr.*	*6th yr.*	*7th yr.*	*8th yr.*	*9th yr.*	*10th yr.*	*11th yr.*	*Total*
1953	269	36	38	6	6	2	1		1	4	2	1	3	64
1954	592	63	78	21	15	14	5	1	5	2	1	2		144
1955	357	39	43	8	15	9	5	2	5	1	1			89
1956	434	48	58	25	7	6	4	1		5				106
1957	270	37	38	7		4	4	2	6					61
1958	251	51	55	5	8	3	1	1						73
1959	579	42	49	12	12	10	9							92
1960	325	27	28	10	8	7								53
1961	270	24	26	4	9									39
1962	452	22	25	22										47
1963	497	63	65											65
Total	4,296	452	503 of 4,296 banded	120 of 3,799 banded	80 of 3,347 banded	55 of 3,077 banded	29 of 2,752 banded	7 of 2,173 banded	17 of 1,922 banded	12 of 1,652 banded	4 of 1,218 banded	3 of 861 banded	3 of 269 banded	833
Percent of bands recovered			11.7	3.2	2.4	1.8	1.1	0.3	0.9	0.7	0.3	0.3	1.1	23.8
Mortality series			49.1	13.4	10.1	7.6	4.6	1.3	3.8	2.9	1.3	1.3	4.6	
Cumulative percent of bands recovered			49.1	62.5	72.6	80.2	84.8	86.1	89.9	92.8	94.1	95.4	100.0	
Survival series			50.9	37.5	27.4	19.8	15.2	13.9	10.1	7.2	5.9	4.6		
Mortality rate			49.1	26.3	26.9	27.7	23.2	8.6	27.3	28.7	18.1	22.0		

* Figures corrected to show direct recoveries if banding had taken place prior to hunting season.

TABLE 2

Life Table for 3,124 Adult Male Lesser Snow Geese Banded Inseason at Tule Lake, California

Banding year May 1-April 30	*Number banded*	*Direct uncorrected*	*Direct corrected* *	*Number of bands returned*										
				2nd yr.	*3rd yr.*	*4th yr.*	*5th yr.*	*6th yr.*	*7th yr.*	*8th yr.*	*9th yr.*	*10th yr.*	*11th yr.*	*Total*
1953	228	18	19	12	6	7	1	1	2		3	7	2	60
1954	505	25	30	16	26	10	6		8	5	2	3		106
1955	367	13	14	11	8	1	7	8	4	2	3			58
1956	257	13	15	17	4	4	4	2		6				52
1957	190	11	11	6	1	5	2		1					26
1958	379	15	16	8	11	9	2	11						57
1959	240	7	7	15	7	1	10							40
1960	281	10	11	7	3	7								28
1961	122	3	3	3	8									14
1962	265	5	5	16										21
1963	290	16	16											16
Total	3,124		147 of 3,124 banded	111 of 2,834 banded	74 of 2,569 banded	44 of 2,447 banded	32 of 2,166 banded	22 of 1,926 banded	15 of 1,547 banded	13 of 1,357 banded	8 of 1,100 banded	10 of 733 banded	2 of 228 banded	478
Percent of bands recovered			4.7	3.9	2.9	1.8	1.5	1.1	1.0	1.0	0.7	1.4	0.9	20.9
Mortality series			22.5	18.6	13.9	8.6	7.2	5.3	4.8	4.8	3.3	6.7	4.3	
Cumulative percent of bands recovered			22.5	41.1	55.0	63.6	70.8	76.1	80.9	85.7	89.0	95.7	100.0	
Survivnl series			77.5	58.9	45.0	36.4	29.2	23.9	19.1	14.3	11.0	4.3		
Mortality rate			22.5	24.0	23.6	19.1	19.8	18.2	20.1	25.1	23.1	60.9		

* Figures corrected to show direct recoveries if banding had taken place prior to hunting season.

TABLE 3

Life Table for 2,884 Adult Female Lesser Snow Geese Banded Inseason at Tule Lake, California

Banding year May 1-April 30	*Number banded*	*Direct uncorrected*	*Direct corrected* *	*Number of bands returned*										
				2nd yr.	*3rd yr.*	*4th yr.*	*5th yr.*	*6th yr.*	*7th yr.*	*8th yr.*	*9th yr.*	*10th yr.*	*11th yr.*	*Total*
1953	257	22	22	4	5	10	4		2	2	1	5		55
1954	465	18	22	17	10	13	5		6	2	3	1		79
1955	339	16	17	9	11	9	7	8	6		5			72
1956	204	13	14	11	8	7	4	2	1	1				48
1957	182	5	6	4	1	5	7		2					25
1958	374	17	17	8	13	12	2	8						60
1959	235	8	9	12	12	1	4							38
1960	222	9	9	5		7								21
1961	116	8	9	1	3									13
1962	217	4	5	12										17
1963	273	9	9											9
Total	2,884			139 of 2,884 banded	83 of 2,611 banded	63 of 2,394 banded	64 of 2,278 banded	33 of 2,056 banded	18 of 1,821 banded	17 of 1,447 banded	5 of 1,265 banded	9 of 1,061 banded	6 of 722 banded	437
Percent of bands recovered				4.8	3.2	2.6	2.8	1.6	1.0	1.2	0.4	0.8	0.8	19.2
Mortality series				25.0	16.6	13.5	14.6	8.3	5.2	6.3	2.1	4.2	4.2	
Cumulative percent of bands recovered				25.0	41.6	55.1	69.7	78.0	83.2	89.5	91.6	95.8	100.0	
Survival series				75.0	58.4	44.9	30.3	22.0	16.8	10.5	8.4	4.2		
Mortality rate				25.0	22.1	23.1	32.5	27.4	23.6	37.5	20.0	50.0		

* Figures corrected to show direct recoveries if banding had taken place prior to hunting season.

TABLE 4

A Comparison of the Vulnerability of Immature and Adult Lesser Snow Geese to Hunter Harvest by Dates

		Immatures Direct band recoveries			*Adults* Direct band recoveries		
		Number	*Percent*	*Accrued*	*Number*	*Percent*	*Accrued*
October	20	4	0.9				
	25	3	0.7	1.6	1	0.4	
	30	13	3.1	4.7	5	2.1	2.5
November	5	13	3.1	7.8	6	2.4	4.9
	10	46	10.6	18.4	19	7.9	12.8
	15	58	13.4	31.8	39	16.1	28.9
	20	38	8.8	40.6	28	11.6	40.5
	25	24	5.6	46.2	16	6.6	47.1
	30	13	3.0	49.2	9	3.7	50.8
December	5	11	2.5	51.7	10	4.1	54.9
	10	27	6.2	57.9	9	3.7	58.6
	15	15	3.5	61.4	6	2.5	61.1
	20	27	6.2	67.6	16	6.6	67.7
	25	24	5.6	73.2	13	5.4	73.1
	30	46	10.6	83.8	22	9.1	82.2
January	5	42	9.7	93.5	15	6.2	88.4
	10	19	4.4	97.9	23	9.5	97.9
	15	6	1.4	99.3	5	2.1	100.0
	20	3	0.7	100.0			
Total		432	100.0		242	100.0	

TABLE 5

Life Table for 10,304 Lesser Snow Geese Banded Inseason at Tule Lake, California

Banding year May 1-April 30	*Number banded*	*Direct uncorrected*	*Direct corrected **	*Number of bands returned*										
				2nd yr.	*3rd yr.*	*4th yr.*	*5th yr.*	*6th yr.*	*7th yr.*	*8th yr.*	*9th yr.*	*10th yr.*	*11th yr.*	*Total*
1953	754	76	79	22	17	19	6	1	5	6	6	13	5	179
1954	1,562	106	130	54	51	37	16	1	19	9	6	6		329
1955	1,063	68	74	28	34	19	19	18	15	3	9			219
1956	895	74	87	53	19	17	12	5	1	12				206
1957	642	53	55	17	2	14	13	2	9					112
1958	1,004	83	88	21	32	24	5	20						190
1959	1,054	57	65	39	31	12	23							170
1960	828	46	48	22	11	21								102
1961	508	35	38	8	20									66
1962	934	28	35	50										85
1963	1,060	88	90											90
Total	10,304	714	789 of 10,304 banded	314 of 9,244 banded	217 of 8,310 banded	163 of 7,802 banded	94 of 6,974 banded	47 of 5,920 banded	49 of 4,916 banded	30 of 4,274 banded	21 of 3,379 banded	19 of 2,316 banded	5 of 754 banded	1,748
Percent of bands recovered			7.7	3.4	2.6	2.1	1.3	0.8	1.0	0.7	0.6	0.8	0.7	21.7
Mortality series			35.4	15.6	12.0	9.7	6.0	3.7	4.7	3.2	2.8	3.7	3.2	
Cumulative percent of bands recovered			35.4	51.0	63.0	72.7	78.7	82.4	87.1	90.3	93.1	96.8	100.0	
Survival series			64.6	49.0	37.0	27.3	21.3	17.6	12.9	9.7	6.9	3.2		
Mortality rate			35.4	24.1	24.5	26.2	22.0	17.4	26.7	24.8	28.9	53.6		

* Figures corrected to show direct recoveries if banding had taken place prior to hunting season.

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TABLE 6

Life Table for 2,682 Lesser Snow Geese Banded Post-Season at Tule Lake, California

Banding year May 1-April 30	*Number banded*	*Number of bands returned*										*Total*
		Direct	*2nd yr.*	*3rd yr.*	*4th yr.*	*5th yr.*	*6th yr.*	*7th yr.*	*8th yr.*	*9th yr.*	*10th yr.*	*11th yr.*	
1953	184		7	9	6	4	2	1		3			32
1954	306		15	8	3	8	7	3	2		1		47
1955	430		14	11	11	10	13	10	1	4			74
1956	408		22	10	8	13	6	2	8				69
1957	536	4	32	9	2	1	12	3					63
1958	625		21	22	14	5	4						66
1959	69	1	4	2	3	12							22
1960	124		8	2	3								13
Total	2,682	5 of 2,682 banded	123 of 2,682 banded	73 of 2,682 banded	50 of 2,682 banded	53 of 2,358 banded	44 of 2,489 banded	19 of 1,864 banded	11 of 1,328 banded	7 of 920 banded	1 of 490 banded		386
Percent of bands recovered		0.2	4.6	2.7	1.9	2.1	1.8	1.0	0.8	0.8	0.2		16.1
Mortality series		1.2	28.6	16.8	11.8	13.0	11.2	6.2	5.0	5.0	1.2		
Cumulative percent of bands recovered		1.2	29.8	46.6	58.4	71.4	82.6	88.8	93.8	98.8	100.0		
Survival series		98.8	70.2	53.4	41.6	28.6	17.4	11.2	6.2	1.2			
Mortality rate		1.2	28.9	23.9	22.1	31.3	39.2	35.6	44.6	80.6			

TABLE 7

Mortality Summary of Lesser Snow Geese Banded at Tule Lake 1953–1960

(Numbers are percentages)

	Male	*Female*	*Immature*	*Age & sex combined*
First year mortality or annual population turnover	24.9	26.3	54.6	38.1
Loss during hunting season	15.4	8.2	46.4	28.7
Loss between hunting seasons	9.5	18.1	8.2	9.4
Total annual loss	24.9	26.3	54.6	38.1

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FOOD OF THE BLUE ROCKFISH *SEBASTODES MYSTINUS*[1]

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The stomachs of 806 blue rockfish, collected during 1962 and 1963, yielded algae, hydroids, jellyfish, crustaceans, tunicates, fish, and a few other types of organisms. These fish came from the Bodega, Monterey, and Morro Bay areas, and ranged from 79 to 450 mm total length; 223 of the stomachs were empty. Food habits were studied by fish size, by depth of occurrence, and by season to determine what changes occurred, if any.

INTRODUCTION

Blue rockfish are among the most numerous of the sport fishes seen in northern and central California partyboat and skiff catches (Miller and Gotshall, in press). A life-history study was initiated in July 1961 to provide the knowledge necessary for managing this important sport fish. Part of this study included determining the species's food habits throughout its principal range, so stomachs from 806 fish were collected. The resulting data were examined to determine the relationships between feeding habits, and fluctuations in catch-per-unit-of-effort, as well as changes in distribution of adult and juvenile concentrations. Emphasis was placed on studying fish in the Monterey area where the most blue rockfish are landed.

METHODS

Preliminary investigations were started in March 1961 to determine what methods would be suitable for a food-habit study. To do this, we collected 50 blue rockfish stomachs during August and September 1961, and evaluated the different procedures and techniques we used in examining them.

Collecting

The specimens we used for stomach analyses were caught with hook and line by partyboat, skiff, pier, and shore fishermen; others were speared by divers. Rotenone, dispersed underwater by Department SCUBA divers, aided in capturing juvenile blue rockfish in the Monterey area.

Most stomachs were collected by project personnel at regular intervals in such a way as to insure a wide distribution of fish sizes and capture depths. In addition, skindiving clubs voluntarily collected stomachs; each club was furnished with the necessary collecting and preserving equipment.

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Collections were made in the Bodega, Monterey, and Morro Bay areas. A minimum of 35 stomachs was saved monthly from July 1962 through June 1963 from each area from pre-selected size categories:

Category	*Size range, mm* TL	*Number of stomachs desired*
I	0–99	5
II	100–199	5
III	200–299	10
IV	300–399	10
V	400–499	5

To compare diets of fish from deep and shallow waters, one-half of the fish in the 200 to 399 mm size groups (III and IV) were collected from deeper than 60 feet, and one-half from shallower.

Stomachs were removed from blue rockfish soon after capture, wrapped in cheese cloth with an identification tag, and immersed in a fixative comprising 40 ml of stock formalin per liter of 50 percent isopropyl alcohol. The formalin was added to impede the leaching of lipids. Stomach contents remained soft and loose, not hard-packed as is characteristic of formalin-fixed material. Capture data were recorded on evelopes inscribed wtih the stomach identification number.

In the laboratory, we opened each stomach; empty ones were noted and discarded. Those containing bait only were also considered empty. Contents were removed under a dissecting microscope and separated into major taxonomic groups. Individual organisms in each taxonomic group were identified, counted, and their volumes measured in a graduated cylinder.

Food Categories

Food categories were compared on the basis of frequency-of-occurrence (percentage), which we believe depicts food preference of blue rockfish.

We grouped food organisms into seven categories: algae, hydroids, scyphozoids, crustaceans, tunicates, fishes, and miscellaneous.

Algae

Green algae, Chlorophyta, comprised approximately one-half the algae observed. Other algae consisted of red, Rhodophyta, and small amounts of brown, Phaeophyta. Generally, algae appeared undigested and was surrounded by a thick mucoid layer. On several occasions, we observed blue rockfish swimming with thalli trailing from the anus.

A large portion of the stomach contents was cellulose-bearing material; how much of this material they are capable of digesting is not known.

Hydroids

We have included hydroids as a separate category because of their abundance in the stomachs of the juveniles. Fish smaller than 100 mm TL fed heavily on hydroids during summer. Our analyses also revealed the commensal relationship of caprillids on hydroids as explained by Ricketts and Calvin (1960).

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Scyphozoids

Jellyfish parts found in stomachs were generally in poor condition and difficult to identify. At times we were able to recognize *Aurelia*, but we also observed blue rockfish feeding on *Pelagia* and *Chrysaora* (Figure 1). The fish were seen stalking jellyfish and biting off pieces of manubrium, which probably contained egg masses; the fish were always alert not to come in contact with the nematocyst-bearing tentacles.

FIGURE 1. Blue rockfish swarming around and feeding on the jellyfish *Chrysaora*. *Photograph by E. Zimbelman, January 1965.*

Crustaceans

Amphipods were most numerous and crab larvae (zoeae) were next most abundant. Small numbers of isopods, cumaceans, copepods, thoracicans, cladocerans, and miscellaneous decapods were recorded. Much of this group was not identifiable because of advanced digestion.

Tunicates

Fish that had been feeding on long chains of tunicates had full and often distended stomachs. Berrill (1961) described solitary, asexual forms of *Salpa* producing many long chains containing 50 to several hundred individuals. Berner (1960) related the same phenomenon for the dolioids. We noted that only the digestive bodies were absorped; the cellulose tunics appeared unaffected and were passed to the intes-

tines. We did not determine genera or species of pelagic tunicates. They were probably representatives of four species reported to be common in Montrey Bay: *Salpa fusiformis* and *Dolioletta gegenbauri* occurring in greatest number; *Salpa democratica* less abundant; and *Doliolum denticulatum* occurring during "warm" seasons (Berner, pers. commun.).

Fishes

We identified about three-fourths of the fish observed in blue rockfish stomachs. Juvenile northern anchovies, *Engraulis mordax*, were most frequently observed, and Pacific herring, *Clupea pallasi*, were second in abundance. We also noted cottids (family Cottidae), unidentifiable larval fishes, and ctenoid and cycloid scales.

Miscellaneous

We classified approximately one-eighth of all stomach contents as miscellaneous. Incidental remains representing several phyla which were placed in this category included annelid worms, nematodes (possibly parasites), ctenophores, trochophore larvae, gastropods, bivalve siphons, and an abundance of cephalopods. About one-half of the miscellaneous matter was unidentifiable. The two most interesting items we noted were one adult fly (Diptera), and one fish hook in good condition.

RESULTS

We examined 806 blue rockfish stomachs: 236 from Bodega Bay, 318 from Monterey Bay, and 252 from Morro Bay (Table 1). Crustaceans, tunicates and scyphozoids (jellyfish), in that order, were the most frequently observed organisms (Figure 2). Tunicates, algae, fish, and scyphozoids formed the highest percent of total volume. In all, 223 stomachs (27.7 percent) were empty.

TABLE 1

Food Volumes Determined for 806 Blue Rockfish Stomachs Collected July 1962–June 1963

Area	*No. of stomachs*	*No. of empty stomachs*	*Percent empty*	*Total food volume (ml)*	*Average food volume (ml)*
Bodega Bay	236	55	23.3	605.4	3.3
Monterey	318	88	27.7	803.5	3.4
Morro Bay	252	80	32.1	504.1	3.0
Totals	**806**	**223**	**27.7**	**1,913.0**	**3.2**

Major differences in contents were observed in stomachs of fish from Bodega Bay when compared with those from other areas (Figure 3). Tunicates occurred in only 9 percent of the Bodega Bay stomachs, compared with 36 and 39 percent in the other areas. Thirty-six percent of the Bodega Bay stomachs contained jellyfish, in contrast to 12 and 18 percent at Monterey and Morro Bay. Algae also had a higher percentage of occurrence: 37 percent for Bodega and 12 percent for each southern area. These differences were probably due to sampling bias, since over one-half of the stomachs from the Bodega Bay area were collected by skindivers in waters shallower than 40 feet. Stom-

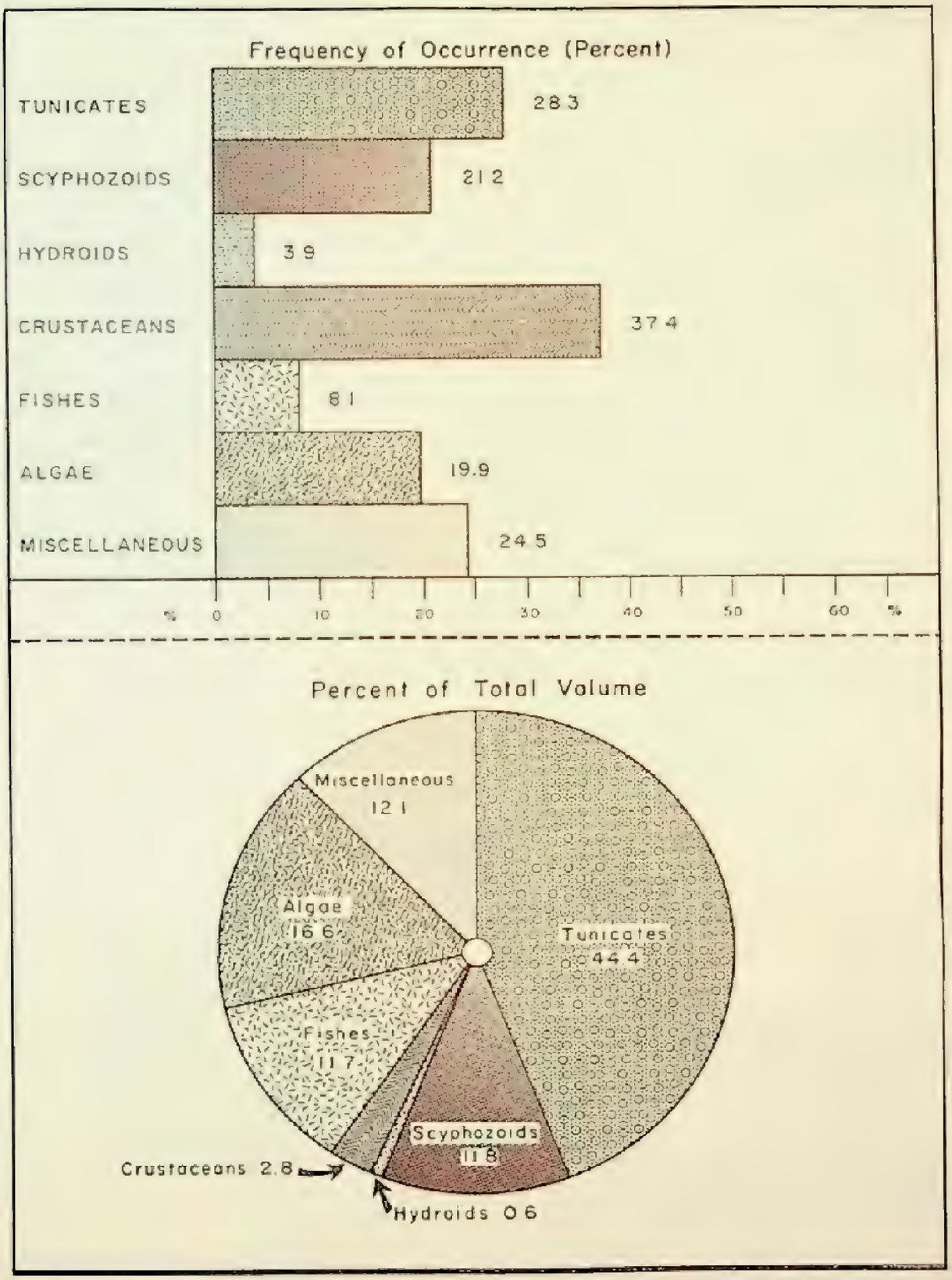

FIGURE 2. Food of blue rockfish taken from Bodega, Monterey, and Morro Bays, July 1962 to June 1963.

achs from the other areas were collected mostly by hook-and-line in deeper water. The low percentage of tunicates suggests these organisms were not as available where stomach samples were obtained off Bodega

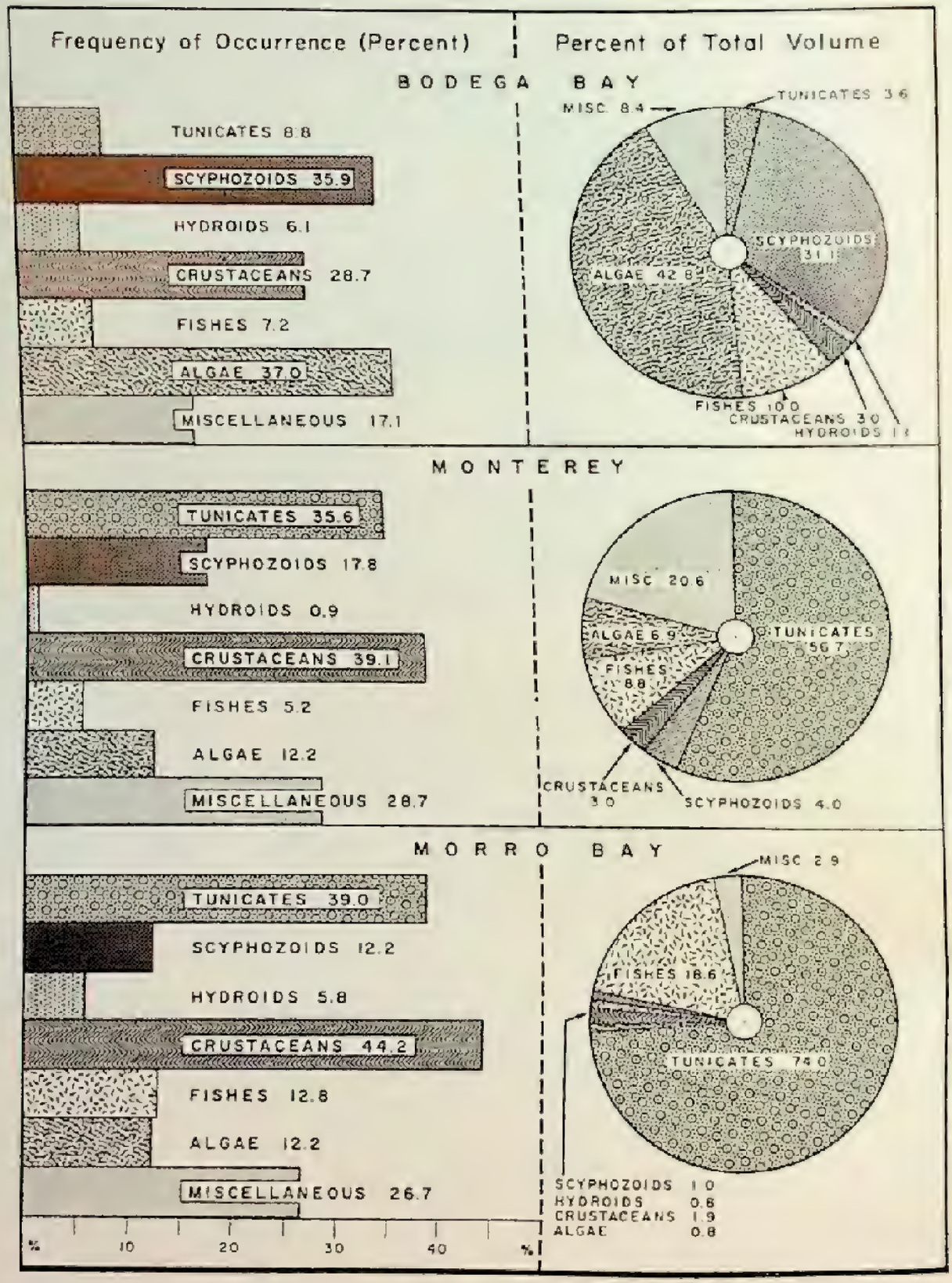

FIGURE 3. Comparison of stomach contents of blue rockfish taken at Bodega, Monterey, and Morro Bays, July 1962 to June 1963.

Bay, or a lesser preference for scyphozoids in areas of tunicate concentrations. The data, therefore, have been combined to show general food patterns for the entire study area and for all depths.

FOOD BY DEPTH

Stomachs were examined from 347 blue rockfish that were caught from known depths: 148 in water shallower than 60 feet, and 199 from deeper. Algae was the most frequently encountered food in shallow-water stomachs, with crustaceans and scyphozoids second and third in

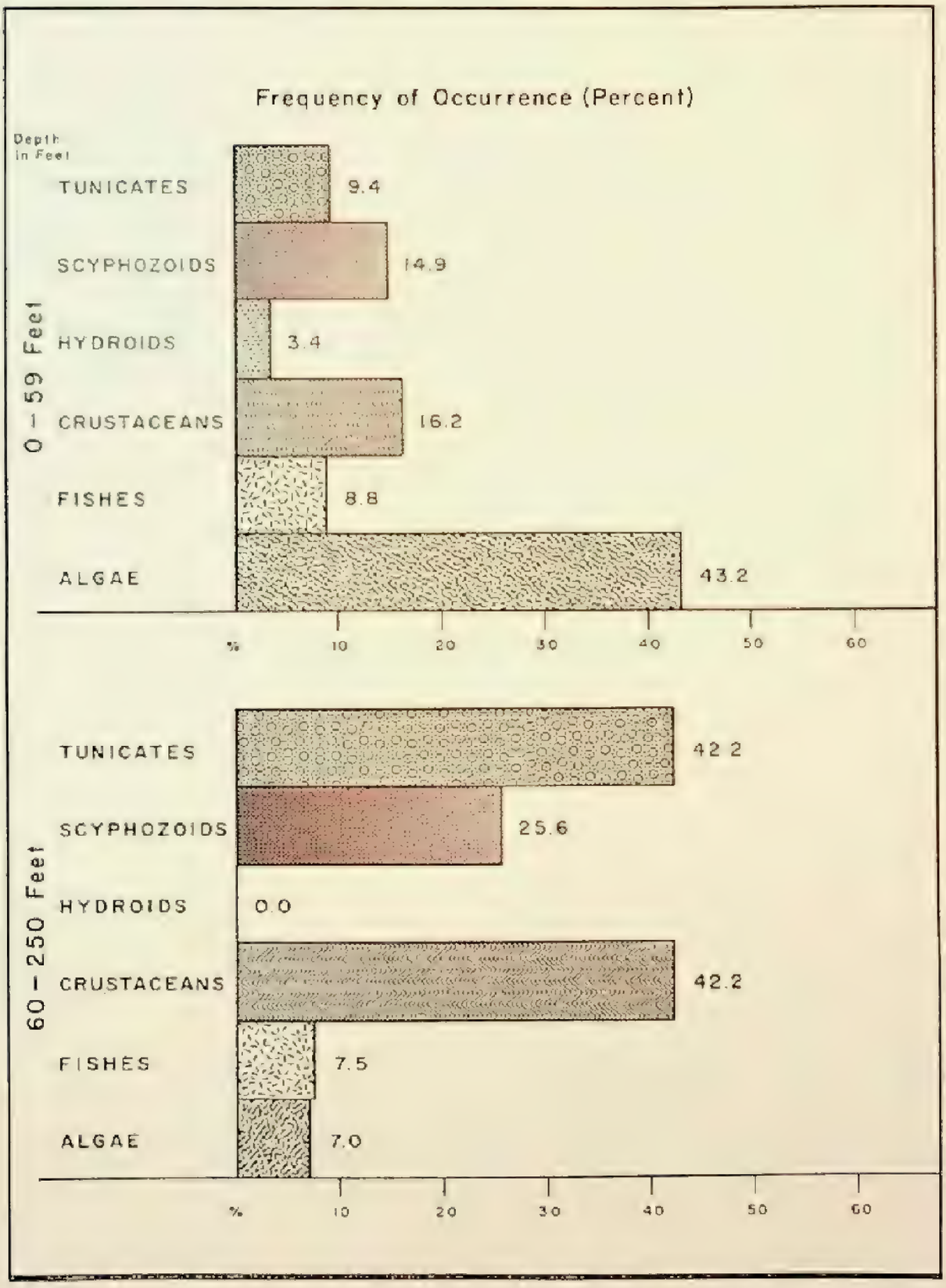

FIGURE 4. Food found in the stomachs of blue rockfish caught in shallow water and deep water at Bodega, Monterey, and Morro Bays, July 1962 to June 1963.

importance (Figure 4). The deep-water stomachs most frequently contained crustaceans and tunicates. Algae showed the smallest percentage-frequency-of-occurrence in stomachs from deep water, and hydroids were entirely lacking.

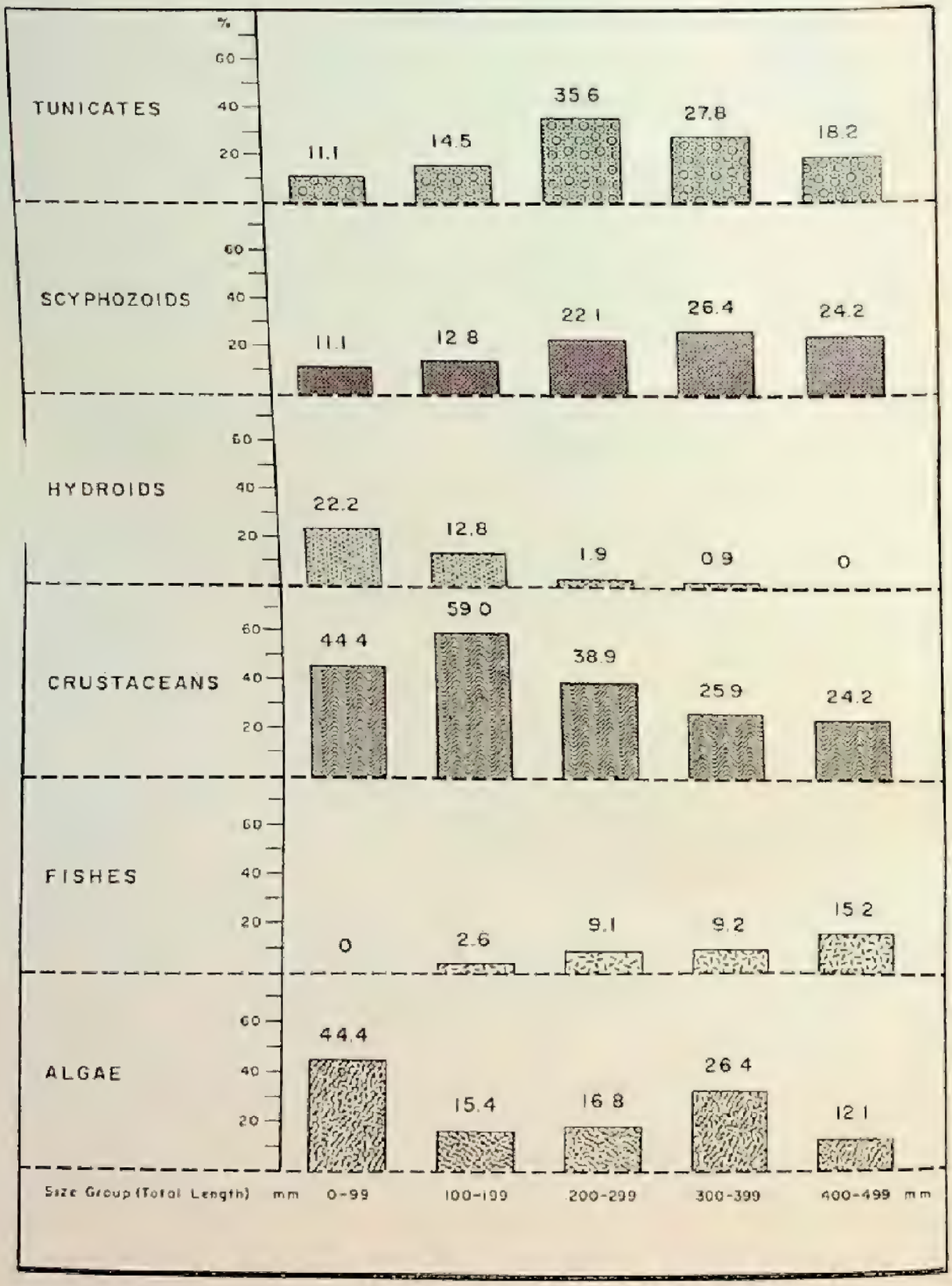

FIGURE 5. Percent frequency of occurrence of food items in stomachs of different sizes of blue rockfish from Bodega Bay, Monterey Bay, and Morro Bay.

Food by Fish Size

For comparing food selection by different size groups of blue rockfish, stomach contents of five size groups were studied separately. We examined stomachs from 9 fish 79–99 mm long, 117 from 100–199 mm fish, 208 from 200–299 mm, 218 from 300–399 mm, and 33 from 400–500 mm.

Crustaceans, algae, and hydroids, in that order, were the most frequently observed food categories found in the stomachs of size group I (Figure 5). Crustaceans, algae, and tunicates were dominant in stomachs of group II fish. Rogers (1958) examined 18 stomachs from blue rockfish, 140 to 198 mm long, caught off Morro Bay during winter 1957–58, and noted that 61 percent contained hydroids. Algae were second in importance while tunicates were not encountered.

Blue rockfish 200–299 mm long (group III) seemed to prefer crustaceans (38.9 percent), with tunicates and scyphozoids second and third.

Tunicates and algae were the two most frequently observed categories in our group IV fish. Stomachs from our largest fish (group V) contained the highest frequency of fish of all size groups examined, but scyphozoids and crustaceans remained dominant.

Generally, larger blue rockfish preferred tunicates, scyphozoids, and fish; crustaceans and algae appeared less frequently.

Seasonal Feeding Habits

A significant difference in monthly feeding habits became apparent when we combined data from the three areas and compared frequencies of the six major food categories (Figure 6).

Tunicates were observed most frequently during December 1962 and May 1963. The lowest frequencies of tunicates were recorded from September through November 1962. Scyphozoids were dominant during September 1962, and hydroids were most frequently observed during August.

Custaceans appeared most frequently during July 1962 and April 1963, and were dominant during July through November 1962 and in April 1963. The lowest frequencies occurred during the winter, particularly in February 1963. Conversely, during February fish and algae were the most frequently encountered items.

Many blue rockfish from the three sampling areas had empty stomachs. Significant sources of error were: (i) bias of individual samplers in selecting the fish stomachs (ii) regurgitation of stomach contents upon capture, and (iii) time elapsing between feeding and preservation of contents. In a study of juvenile striped bass, *Roccus saxatilis*, copepods were completely unrecognizable and only detritus remained after 6 hours in their stomachs (Heubach, Toth, and McCready, 1963).

Assuming the above sources of error operated constantly, we compared the percentage of empty stomachs and average volume of contents by month. This yielded information about seasonal feeding habits of blue rockfish. Generally, the period from October through March was characterized by a higher percentage of empty stomachs, and low

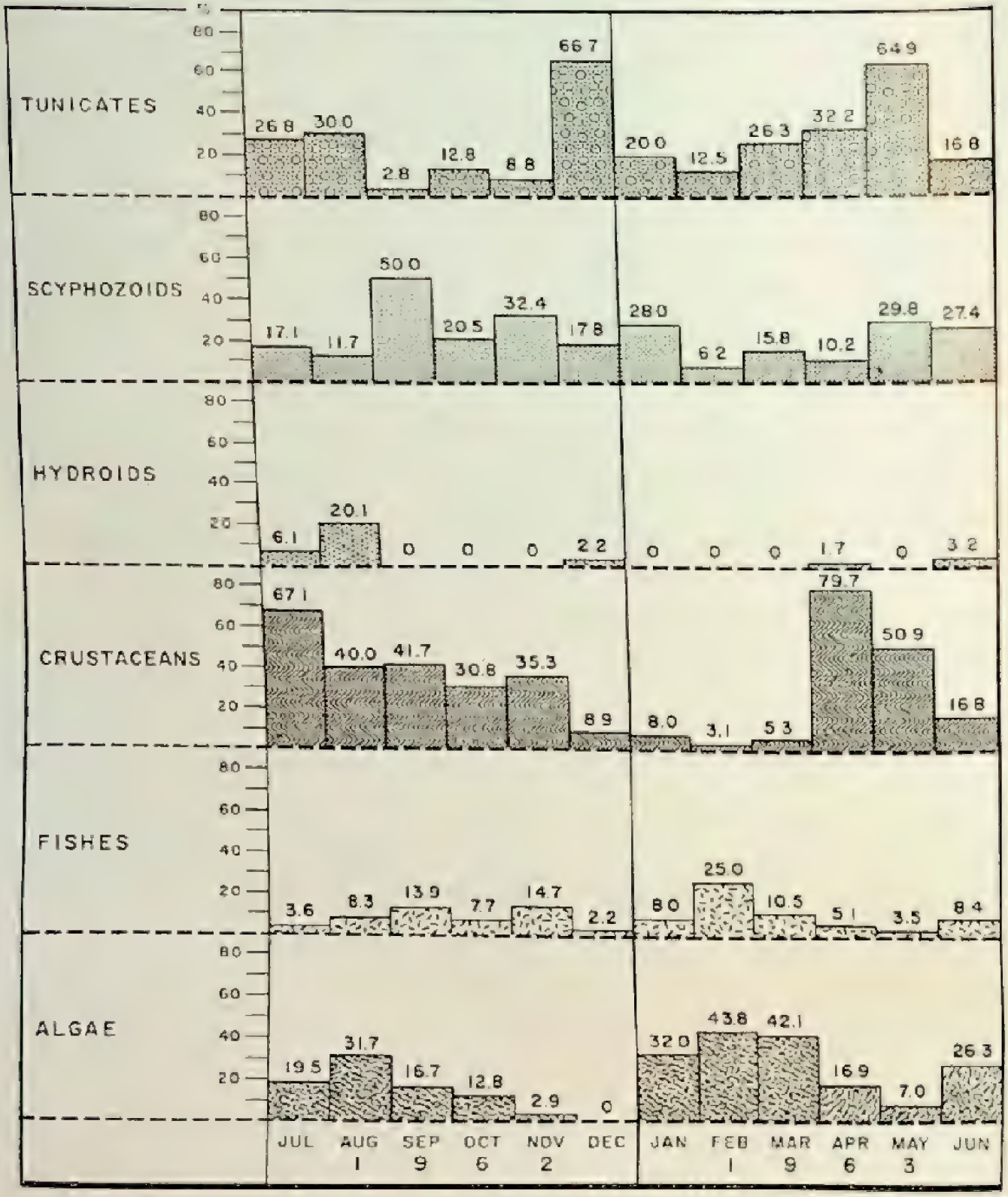

FIGURE 6. Frequency of food items in stomachs of blue rockfish from Bodega, Monterey, and Morro Bays, July 1962–June 1963.

average volumes of food organisms. April through September was characterized by a lower percentage of empty stomachs and high average volume (Figure 7). The latter was also a period of low catch-per-unit-of-effort in the partyboat fishery, particularly during April and May.

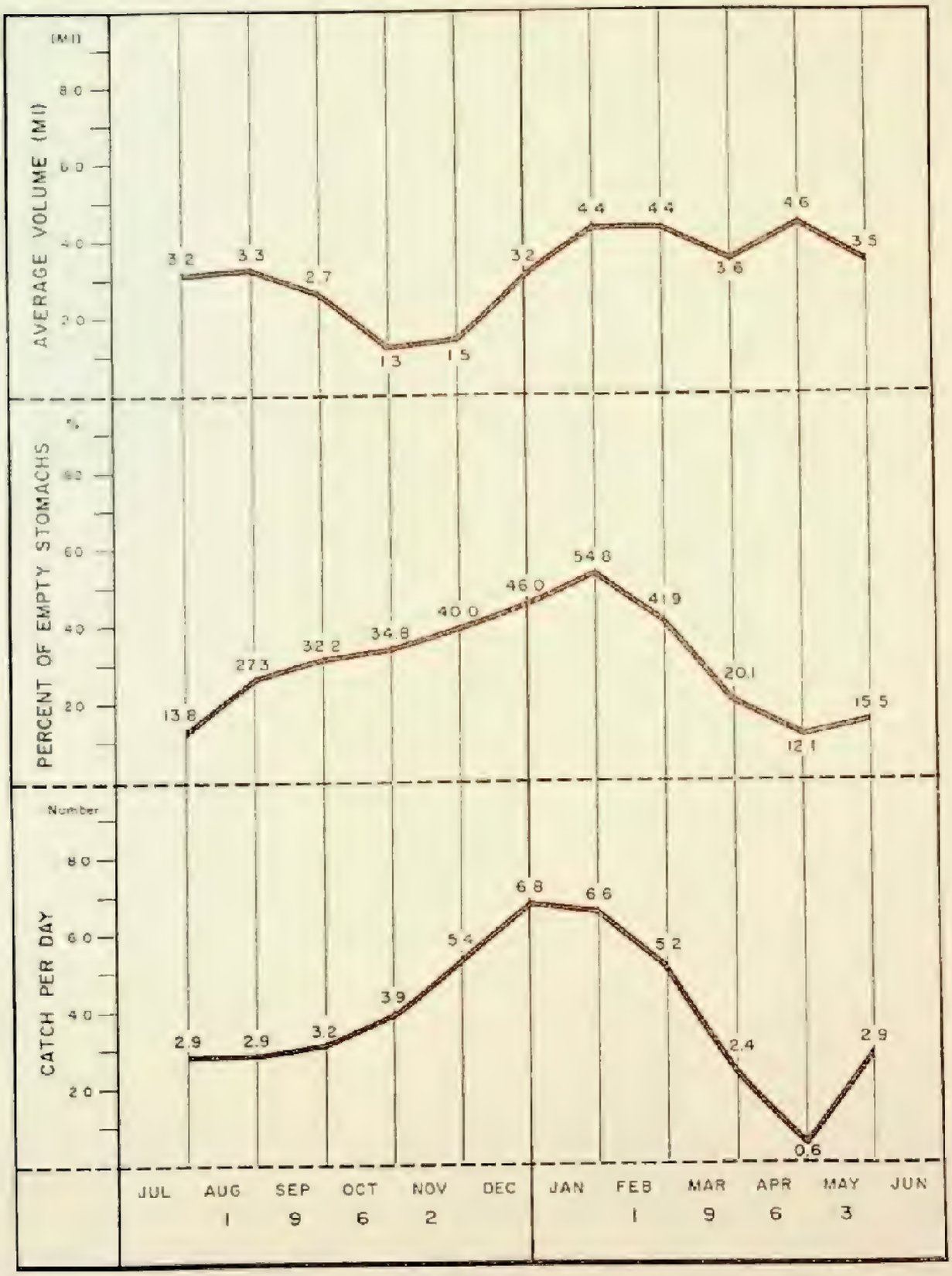

FIGURE 7. Comparison of average volume of food, and percent of empty stomachs with the catch-per-day of blue rockfish by partyboat anglers at Bodega, Monterey, and Morro Bays, July 1962–June 1963. (The data were smoothed by moving average of three.)

DISCUSSION

The food study of blue rockfish was inaugurated primarily to determine what effect their feeding activities might have on catch-per-unit-of-effort of the central California partyboat and skiff fisheries. Sampling these fisheries during 1959 and 1960 at ports between Bodega Bay and Avila revealed a decrease in the catch-per-day of blue rockfish from April through early June (Miller and Gotshall, in press). Partyboat operators report blue rockfish are often difficult to catch during the spring.

We have a continuous record of catch-per-day for the Monterey partyboat fishery from January 1960 through December 1963, and during this period, the lowest catch-per-day of blue rockfish consistently occurred during May, with April the next lowest month. The catch-per-day usually increased during June (1960, 1962, 1963) or July (1961) (Figure 8).

We found that the catch-per-hour of blue rockfish in the Monterey skiff fishery was lowest during April 1959, and March and May 1963 (Figure 9). This period of low catch-per-unit-of-effort probably occurs annually in both the partyboat and skiff fisheries.

Underwater observations, made during the April-May 1963 cruise of the Department's research vessel *N. B. Scofield* at San Miguel Island and off Davenport, suggested that when large quantities of food organisms (crustaceans at San Miguel Island, and tunicates off Davenport) were available, blue rockfish showed no interest in baited hooks (Gotshall, 1963). We experienced low catch-per-unit-of-effort on the 1963 cruise around the Farallon Islands when large concentrations of tunicates, crustaceans, ctenophores, and other macro-zooplankton were present.

Two reasons for a seasonal decrease in blue rockfish catch-per-unit-of-effort were considered: (i) during April and May, the fish may migrate from the sportfishing areas; or (ii) a change of feeding habits may occur because of some physiological factor (e.g., spawning) or because food is more available on the fishing grounds.

Preliminary tagging results indicate that blue rockfish do not migrate; indeed, most tag returns have been from the exact area of release. Thus, a change in feeding behavior remained as a possible cause for decreases in catch-per-unit-of-effort.

Wales (1952) reported that blue rockfish spawn between November and January. Our observations indicate that most females are extruding eyed eggs during this period. Unless some post-spawning physiological change occurs, spawning would not affect feeding behavior during April and May.

We believe these annual decreases in catch-per-unit-of-effort that have occurred during April through May (at least since 1960) were due, in part, to a superabundance of zooplankton. Although crustaceans and tunicates were the principal organisms we found in their stomachs during April and May, the causative organisms probably differ from year to year. This is supported by observations made on the 1963 *N. B. Scofield* cruise (Gotshall, 1963). During periods of low catch-per-unit-of-effort, we found the percentage of empty stomachs not only was low, but there was a high average volume per stomach. Bolin and Abbott (1963) indicated that heaviest plankton concentrations generally occur

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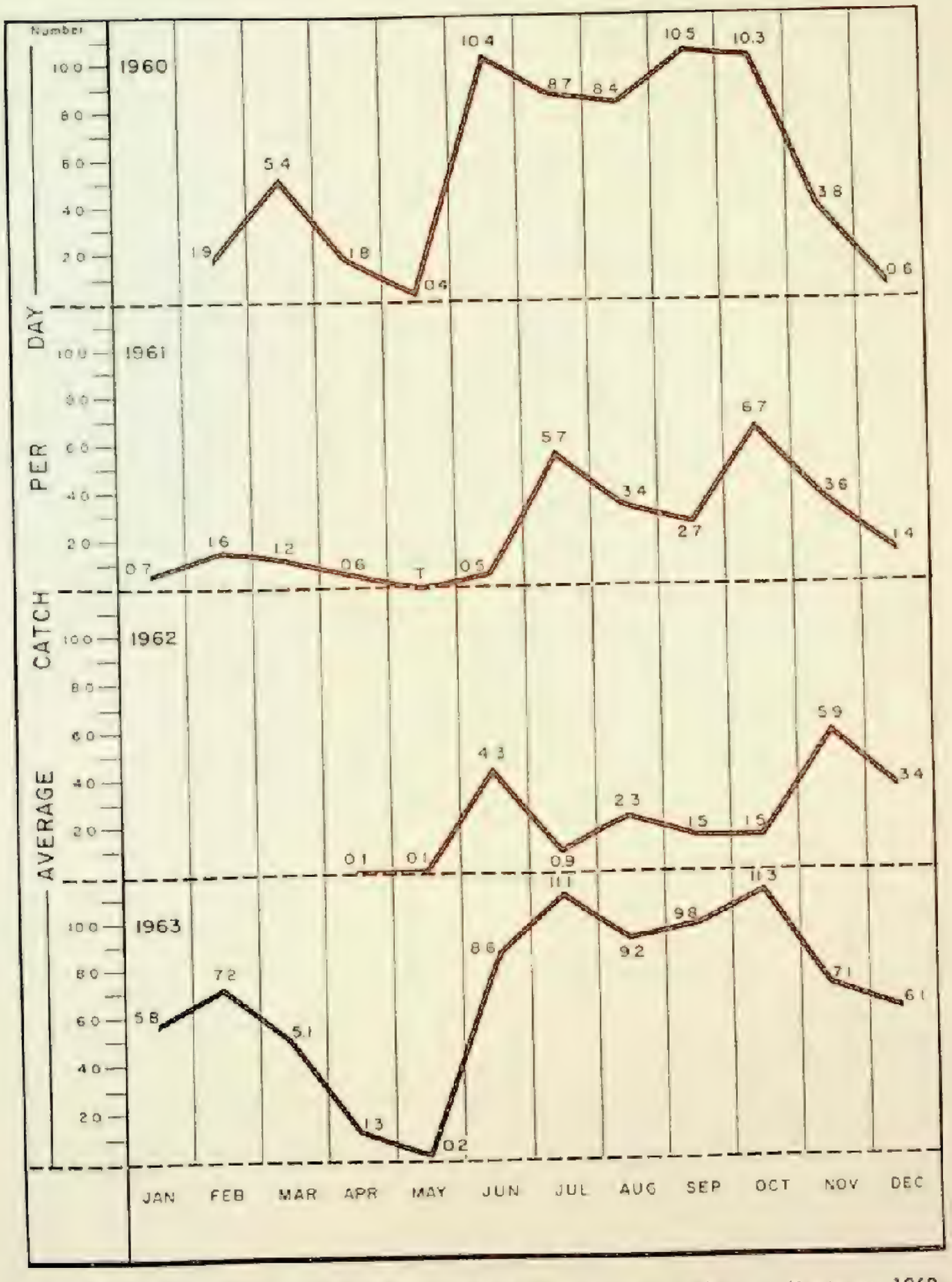

FIGURE 8. Average catch-per-day of blue rockfish by partyboat anglers, at Monterey, 1960–1963. (No data are available for February 1960; January, February, and March 1962; and January 1963.)

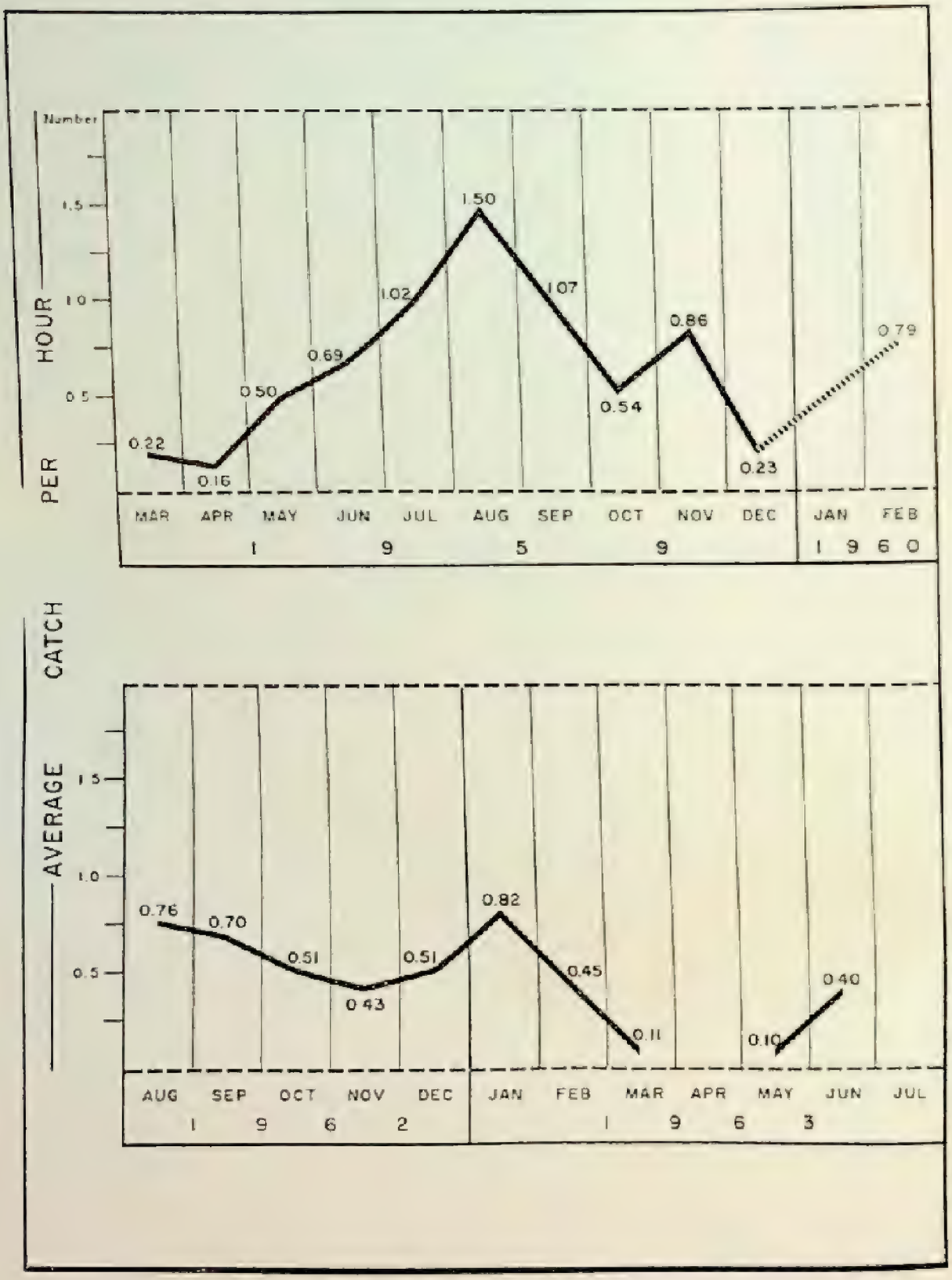

FIGURE 9. Average catch-per-hour of blue rockfish by Monterey skiff anglers, March 1959, February 1960, August 1962, June 1963. (No data are available for January 1960 or April 1963.)

during and after periods of upwelling, and that in Monterery Bay the upwelling period is February through September. Skogsberg (1936) believed the upwelling period in Monterey Bay extended from the middle of February through the end of July.

L. D. Berner (pers. commun.) feels that large populations of tunicates are related to upwelling and associated blooms.

Blue rockfish are apparently "opportunity" feeders, i.e., feeding on whatever food is available. Since a major part (59.0 percent of the volume) of their diet consisted of zooplankters (crustaceans, scyphozoids, tunicates), we assume that most feeding occurs above the bottom, particularly among adults and pelagic larvae. These fish probably feed on bottom organisms only as early juveniles, and when planktonic food is scarce. Because they do feed to a large extent on zooplankton, blue rockfish possibly could be used as "indicator" organisms to determine relative annual abundance of larval crustaceans and fish.

Our data suggest that blue rockfish are "selective opportunity" feeders rather than "selective demand" feeders. Apparently a drastic decrease in any one of their major food items would not affect the sizes of blue rockfish populations. Prolonged zooplankton shortage in a particular area might, however, cause their temporary movements in search of food.

SUMMARY

1) Blue rockfish are one of the most numerous species caught by northern and central California partyboat and skiff fishermen. In July 1961, a blue rockfish life-history study was undertaken; part of this study was an investigation of their food habits.

2) Between July 1962 and June 1963, 806 stomachs were examined; 223 of these were empty. The three most frequently observed items were crustaceans, tunicates, and scyphozoids, while tunicates, algae, fish, and scyphozoids contributed the highest volumes.

3) Algae were most frequently encountered in stomachs collected from water shallower than 60 feet; while crustaceans and tunicates were most often found in fish caught in deeper water.

4) Generally, as the size of blue rockfish increased, tunicates, scyphozoids, and fish appeared more frequently in their diets, while hydroids, crustaceans, and algae were observed less frequently.

5) Tunicates were most often found in stomachs collected during the winter and late spring, jellyfish during late summer, crustaceans during spring and summer, and algae and fish during late winter.

6) Fall and winter months were characterized by a high percentage of empty stomachs, and low volumes of food. Conversely, spring and summer months were periods of few empty stomachs and high average food volumes.

7) We believe the low annual catch-per-unit-of-effort of blue rockfish occurring during April and May is, at least in part, directly related to upwelling and increased zooplankton populations.

8) Fluctuations in abundance of a particular food item probably do not affect the size of blue rockfish populations; prolonged absence of zooplankton in a specific area might cause a temporary population shift.

ACKNOWLEDGMENTS

The task of collecting blue rockfish stomachs was not always rewarding. Several project seasonal aids and volunteer skindivers spent many hours obtaining fish to meet sample requirements.

Partyboat operations donated work space, and assisted in locating and collecting fish.

Richard B. Mitchell and crew of the *N. B. Scofield* assisted in seeking out and collecting blue rockfish.

Laboratory facilities and equipment were procured through the efforts of John P. Harville, Professor of Biology and Science Education, San Jose State College.

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The manuscript was typed by Clare Moseley.

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INTRASPECIFIC EYE LENS PROTEIN DIFFERENCES IN YELLOWFIN TUNA, *THUNNUS ALBACARES*

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Soluble eye lens proteins of yellowfin tuna were tested by anti-lens serum, cooling, heating, and electrophoresis. Each method indicated that some lenses contain proteins not found in others. This information, together with a consideration of lens anatomy, suggests that procedures performed on the lens are applicable to the problem of identifying individual breeding populations.

Electrophoretic and immunologic methods have been widely used to analyze soluble tissue proteins of various higher animals. Wood, Massi and Solomon (1954) demonstrated the presence of five protein components in the rabbit lens; Halbert *et al.* (1957) also found five antigens in rabbit lenses. Immunologic studies by Rao *et al.* (1955) suggested that beef lenses contain at least six different antigens. Wood and Burgess (1961) electrophoresed lens proteins of cows, hogs, dogs, sheep, cats, and chickens and found five components in each species. None of these authors, however, described protein variation within any one species.

Fish eye lenses were first studied electrophoretically at the California State Fisheries Laboratory when Smith (1962) examined the soluble lens proteins of kelp bass (*Paralabrax clathratus*), bluefin tuna (*Thunnus thynnus orientalis*), and albacore (*Thunnus alalunga*). The kelp bass and bluefin tuna demonstrated two components with similarly shaped curves; the albacore showed one component in two different shapes, indicating protein variation between individuals. These results encouraged me to see if this technique, and others involving the eye lens, could be used for determining protein differences attributable to genetic variation in the yellowfin tuna, which was selected because satisfactory numbers were available at all times.

The eye lens core or nucleus is comprised of fibers that have sclerosed and died during formation because they lacked intrinsic circulation and had been removed from sources of dietary protein and oxygen (Walls, 1942). Thus the nucleus contains only genetically determined structural proteins—some readily soluble and ideal for studying genetic variation. Methods for detecting such variation are of considerable importance to fishery biologists who find it necessary to identify separate breeding populations.

In this study, I treated lens extracts in four ways: (i) with anti-lens serum, (ii) by cooling, (iii) by heating, and (iv) by electrophoresis; and I evaluated each as a means of identifying unequally occurring lens proteins within the same species, and for its application in distinguishing separate populations.

EXPERIMENTAL METHODS AND RESULTS

A lens was removed from each of 108 yellowfin tuna and freed of aqueous and vitreous humor, pieces of retina, and capsule; it was then placed in a dry bottle and stored frozen until ready for use.

Protein extracts were prepared by mechanically mincing the lens nucleus from each tuna in a 0.9 percent saline solution and storing at 0° to 5° C for 24 hours.

Six experiments were performed with these extracts:

Test 1) An anti-lens serum was prepared by injecting 1 ml of extract from a single lens nucleus (nucleus = 175 mg, saline = 20 ml) into the marginal ear vein of an 8-month-old, 3-kg. rabbit according to the following schedule: first 2 weeks, six injections, third week, two injections; and fourth week, two injections. Serum of high titer was obtained 5 days after the last injection. Rabbit serum (0.5 ml) was added to serial dilutions of 0.5 ml lens extract, and the tubes were examined after 4 hours room temperature incubation; the one containing a 1:2 ratio of antiserum to antigen gave ample precipitate, so this convenient ratio was used in testing separate aliquots from each of 40 lens extracts with the anti-lens serum. Adding antiserum produced a precipitate in 85 percent of the tubes.

Test 2) Other aliquots from these 40 extracts were refrigerated at 0° to 2° C. Ten days later the contents of 85 percent of the tubes were cloudy.

Test 3) Additional aliquots from the same 40 extracts were placed in a constant-temperature bath at 64.5°C. After 3½ to 4 minutes of incubation under constant agitation, 55 percent of the tubes contained precipitated protein.

Test 4) Aliquots from 52 lens extracts were refrigerated at 0° to 2° C and read daily for 3½ weeks to note developing cloudiness. In 24 hours, the contents of nine tubes showed some clouding; after 48 hours, 34 tubes had cloudy contents. These became increasingly cloudy with time, and eventually the solution in the nine tubes that had remained clear began to cloud. Readings stabilized in about 2 weeks, with the contents of almost every tube clouded to some degree. By the end of the test, the solutions had developed foul odors, and all were cloudy.

Test 5) Separate aliquots from the same 52 extracts were heated gradually in a water bath. In these, cloudiness began at temperatures as low as 62°C (1 tube), and as high as 70°C (1 tube), while protein began to precipitate at temperatures as low as 67°C (3 tubes) and as high as 79° C (1 tube). Cloudiness developed in most tubes (15) at 67°C, and precipitation began in most tubes (11) at 72°C (Figure 1).

Test 6) The remaining 16 samples of lens extract were treated with Grönwall's (TRIS) buffer, prepared according to the directions of Aronsson and Grönwall (1958), and processed in a Spinco Model R Electrophoresis Apparatus. A current of 5.0 ma per cell was allowed to flow 24 hours. After complete separation, the paper strips con-

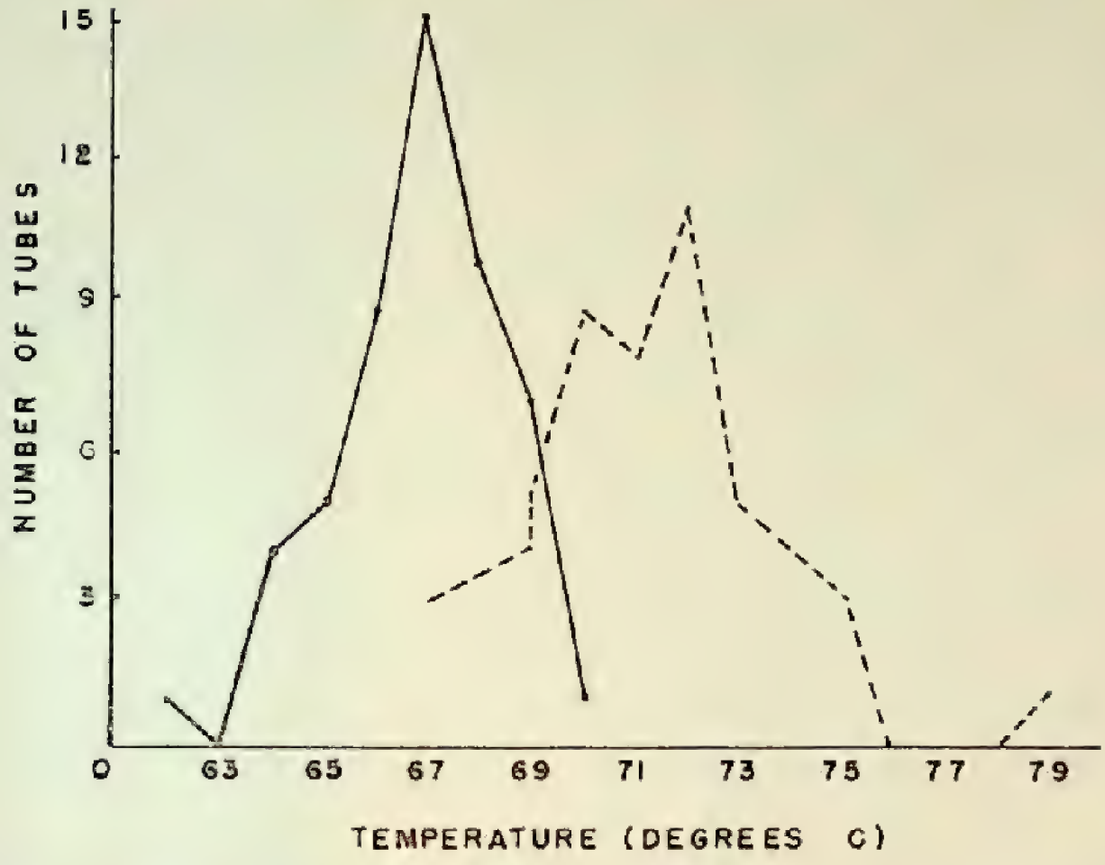

FIGURE 1. Temperatures at which yellowfin tuna soluble lens proteins begin to coagulate: Solid line = first cloudiness, broken line = first precipitate.

taining the protein concentrations were oven-dried at 118° C, immersed in bromphenol blue dye (Spinco B1) for 6 hours to overnight, rinsed twice in 5 percent glacial acetic acid (6 minutes each), and rinsed once in a solution of 5 percent glacial acetic acid containing 20 ml of supersaturated sodium acetate solution (6 minutes). The strips were dried again at 118°C, and then placed in ammonium hydroxide vapor for 15 minutes. The components on the paper strips were evaluated with a Spinco Model RB Analytrol.

Three types of curves were demonstrated: one with two major components, another with two major components and a minor component, and finally, one with two major and two minor components (Figure 2).

DISCUSSION

Some lens proteins were antigenic and produced an anti-lens serum. Since a precipitate formed in most tubes, this anti-serum was specific against only one or very few proteins found in most of the lenses. If the serum had contained less-specific antibodies, I would have expected protein precipitation in every tube of extract.

Eye lens proteins also were precipitated by cooling the extracts at a set temperature. Keeping them cool for a time revealed that differential clouding took place. About 2 weeks were required for the tubes with coagulated protein and for their degree of turbidity to stabilize, but it was difficult to determine when bacteria began to grow, and affect solution turbidity.

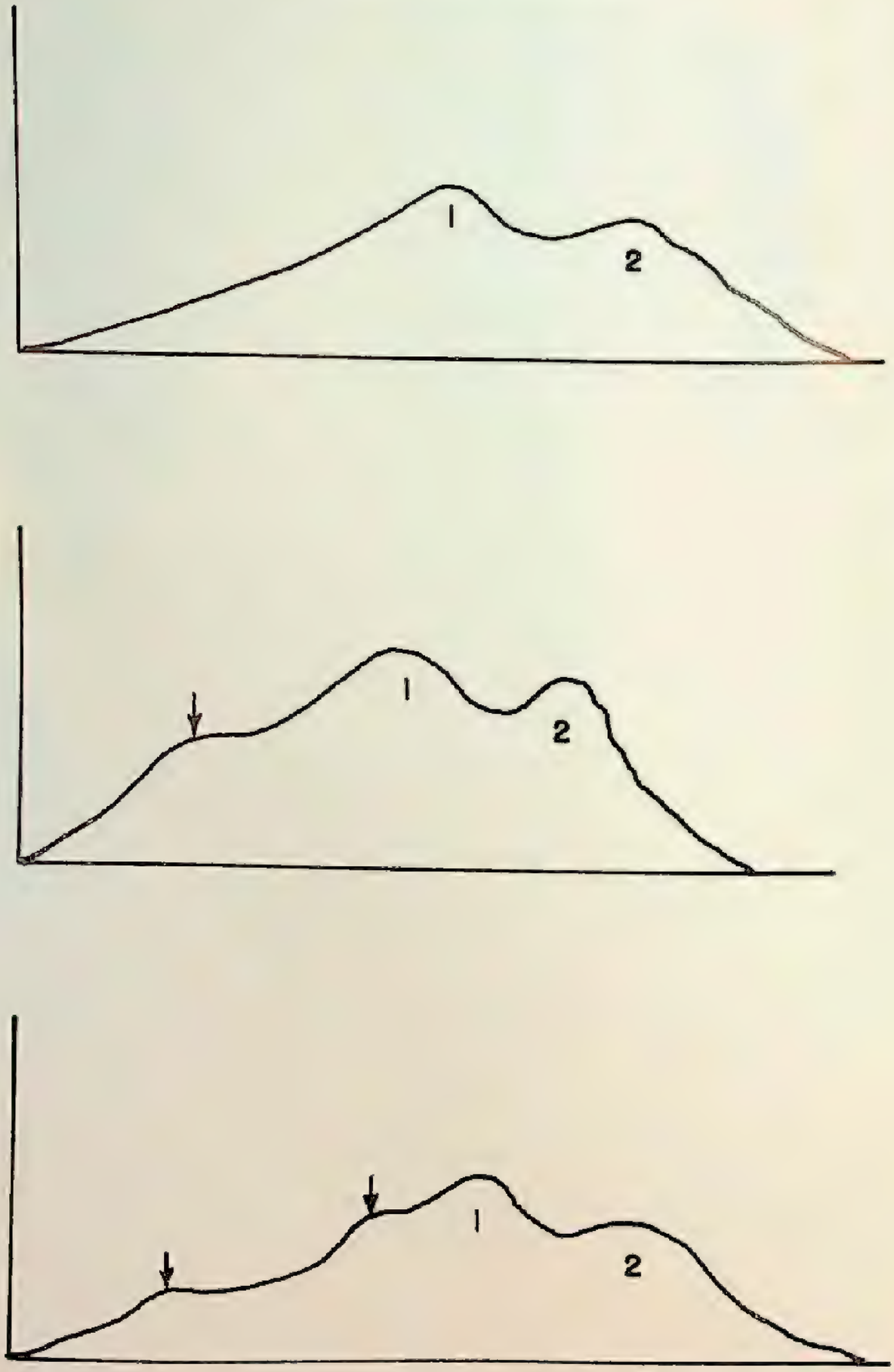

FIGURE 2. Electrophoretic patterns of yellowfin tuna soluble lens proteins. Major components are numbered, and minor ones are indicated by arrows.

Heating eye lens extracts, by contrast, produced rapid and clear differential precipitations of protein; no waiting period was necessary, so no complications were caused by bacterial growth.

Electrophoresis of soluble lens proteins produced three patterns. The differences between them were presumably due to genetic differences within yellowfin tuna. Two major components were common to all three patterns; and the absence, or presence and number of minor components produced the pattern variations.

Although cooling proved unsatisfactory, the application of anti-lens serum, heating, and electrophoretic techniques for identifying unequally occurring lens protein in yellowfin tuna showed considerable promise. All three methods are applicable to the problem of population differentiation, because they can be used to detect significant differences in the frequency of occurrence of eye lens proteins.

Population identification by blood genetics methods has been most widely used to date, but there are inherent disadvantages: (i) much of the work must be performed at sea, and (ii) the development of reagents is often tedious and difficult. By comparison, methods of treating eye lenses are relatively simple and can be performed in the laboratory when convenient. Also, changes in geographic location and extent of the one or more populations being investigated can be monitored routinely by sampling lenses from the fishermen's catches, frozen or fresh, when they are landed at the waterfront.

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PACIFIC MACKEREL, THE COMMERCIAL FISHERY, AND AGE COMPOSITION OF THE SOUTHERN CALIFORNIA CATCH FOR THE 1961–62, 1962–63 AND 1963–64 SEASONS[1]

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The Commercial catch of Pacific mackerel *(Scomber diego)* off California was 44, 45, and 34 million pounds respectively during the 1961–62 through 1963–64 seasons. The most productive fishing grounds were in southern California where approximately 55 percent of each season's landings came from offshore islands and banks. Roundhaul net boats caught 95 to 98 percent of the landings during the three seasons. Landings were dominated by four successive large year-classes (1958 through 1961).

The price was stable at $42.50 per ton until February 26, 1964, when it was raised to $47.50 per ton.

If landings are to remain above 34 million pounds, at least one, above-average year-class must be recruited to replace those which are dwindling.

In this 10th report on the age composition of Pacific makerel, we wish to thank David J. Mackett, of the Department's Biostatistical Section for his aid with the computer program by which the data for the three seasons were processed. We greatly appreciate the efforts of Anita E. Daugherty and others who aided in sampling the commercial catch and Gertrude M. Cutler for her work on the charts and tables.

The methods of sampling and age determination are fundamentally the same as those used by Fitch (1951). The method of estimating numbers of fish by age has been modified for computer analysis (Appendix A). In the three seasons reviewed, 832 otoliths (422, 205, and 205 respectively) were read to form the basis for the analysis (Appendix B, C, and D).

Pacific mackerel commercial landings for the period May 1 through April 30 of the 1961–62, 1962–63, and 1963–64 seasons were 44, 45, and 34 million pounds respectively (Table 1). Monthly landings during these seasons were irregular, fluctuating between 150 and 6,000 tons. May, October, and November were the months of highest average landings, while June, February, March, and April were below average.

A 5-week tie-up of the southern California fleet, September 1 to October 8, 1962, depressed September 1962 landings. Reduced landings during January, February, and March of 1964 were due to storms, a fleet tie-up, and a reduced population of Pacific mackerel on the fishing grounds.

On March 20, 1961, the price fishermen received for both jack mackerel (*Trachurus symmetricus*) and Pacific mackerel was raised from $35 to $42.50 a ton. This amount was paid until February 26, 1964,

[1] Submitted for publication March 1965.

TABLE 1
Statewide Pacific Mackerel Landings

Month	*Season*		
	1961–62 *Thousand pounds*	*1962–63* *Thousand pounds*	*1963–64* *Thousand pounds*
May	5,569	4,021	6,669
June	1,042	2,200	1,757
July	3,414	3,227	1,416
August	2,581	4,698	4,684
September	2,869	1,842	2,271
October	6,381	11,646	8,589
November	7,135	6,176	3,238
December	3,764	3,223	3,398
January	6,035	1,440	302
February	3,384	1,891	442
March	860	2,250	305
April	1,267	2,640	1,140
Totals	44,301	45,254	34,211

when mackerel prices for the entire canning industry were set at $47.50 a ton, thus ending 10 weeks of fleet inactivity, which began December 19, 1963. The central California fleet was not affected by this tie-up. During most of January and February, 1964, pet-food canners in southern California, who usually process a minor portion of the catch, paid fishermen $52.50 per ton for both mackerels.

During the three seasons, the most productive fishing grounds were in southern California (Table 2 and Figures 1, 2, 3). Offshore banks and islands, excluding the Northern Channel Islands area, accounted for approximately 55 percent of the landings during each season. Coastal areas from Santa Barbara south, contributed most of the remainder. This general pattern is consistent with 1959–60 and 1960–61 (Hyatt, 1965) with one significant difference. During 1959–60 and 1960–61, landings at Cortes and Tanner Banks were virtually zero; since then, this area has yielded approximately 20 percent of the total catch. Historically, less than 2 percent of the seasonal landings have come from these banks, except in 1952–53 when they contributed 51 percent.

During these same seasons, about 20 tons of Pacific mackerel were caught off central California (Table 2), 60 percent from the vicinity of Piedras Blancas, nearly all in mixed loads of jack mackerel or Pacific sardines (*Sardinops caeruleus*). In addition, approximately 3 million pounds of Pacific mackerel, caught in southern California, were trucked to Monterery Bay canneries from Port Hueneme.

Fishermen using roundhaul nets, including purse seiners, lamparas and variations thereof, landed 95, 99, and 98 percent of the catch during 1961–62 through 1963–64 seasons respectively (Table 2). About 94 percent of the remainder, were landed by boats equipped with scoop and/or striker gear. The number of net boats making deliveries declined from 99 in 1961–62 to 83 the following season, and to 78 in 1963–64. During the same period boats using scoop and striker gear declined from 64 to 16 and then rose to 18.

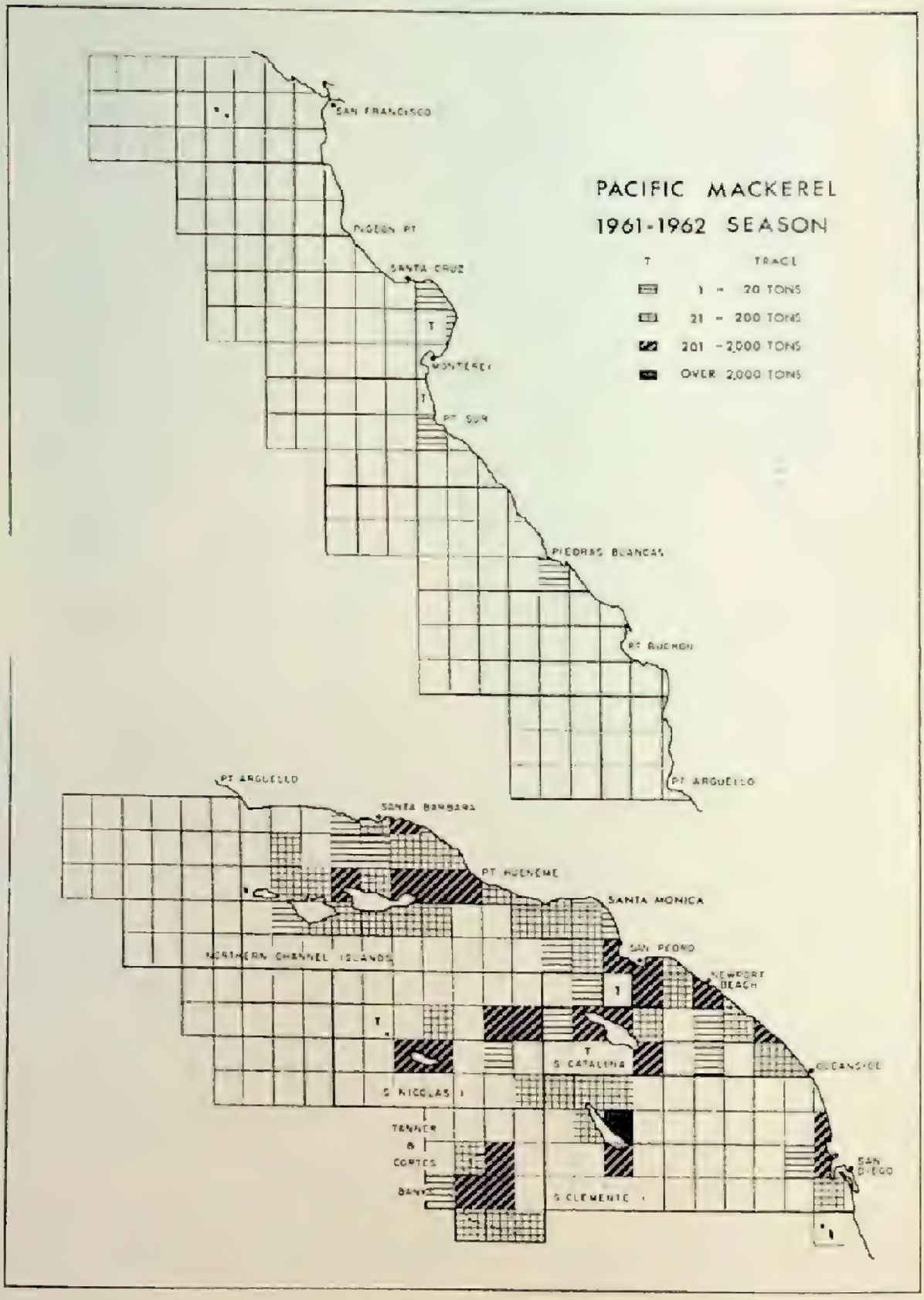

FIGURE 1. Pacific mackerel catch origins 1961–62 season.

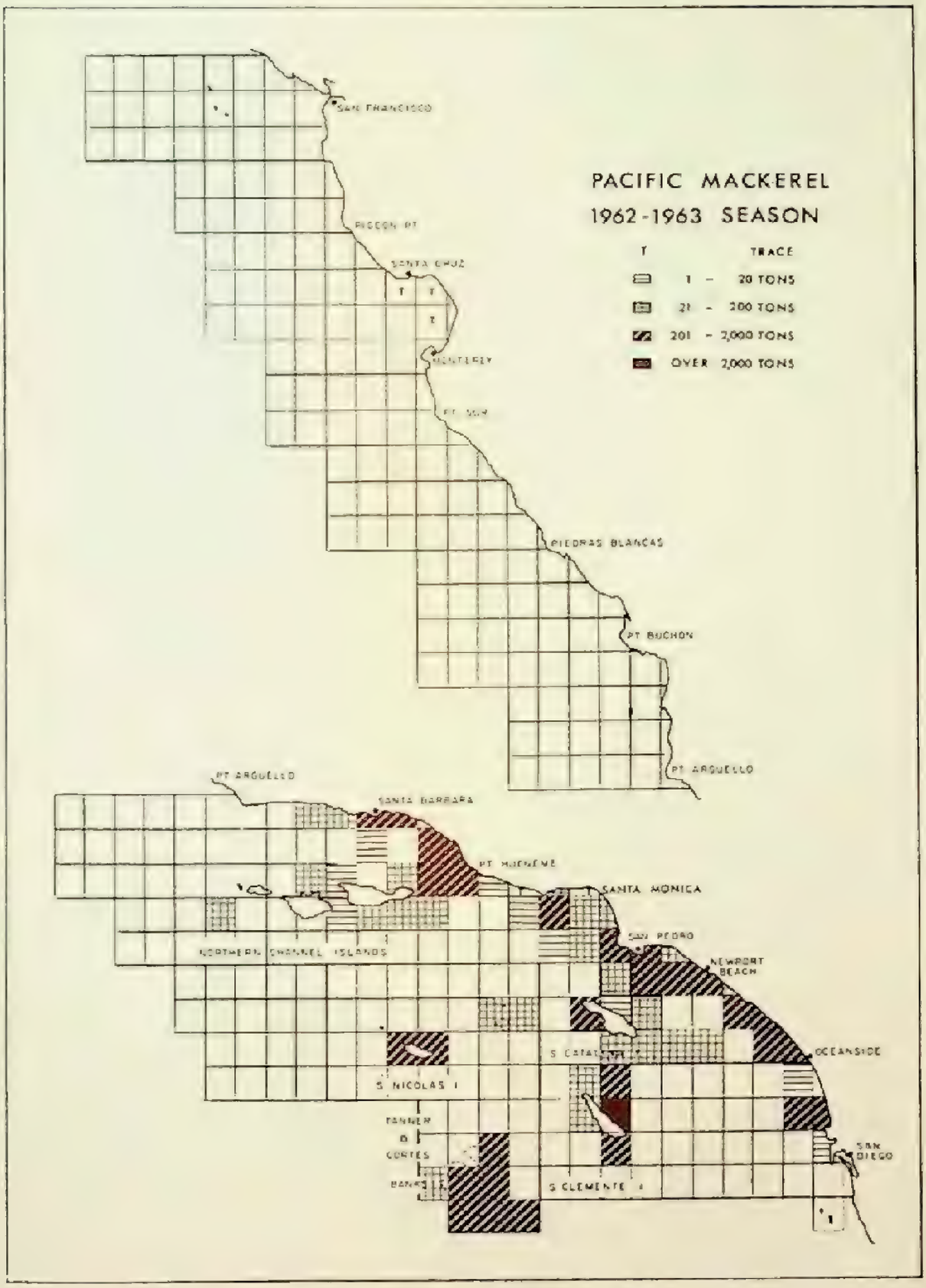

FIGURE 2. Pacific mackerel catch origins 1962–63 season.

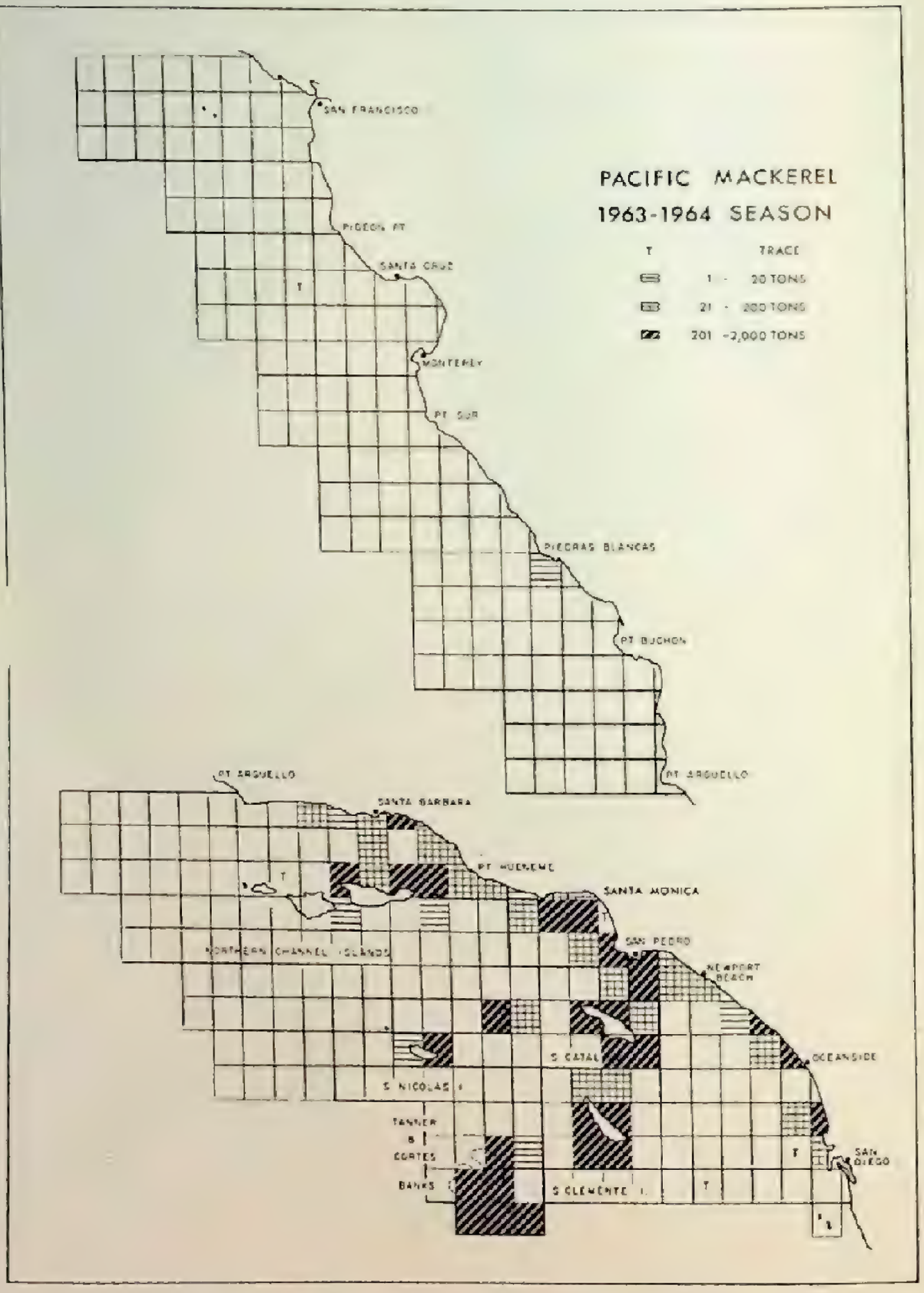

FIGURE 3. Pacific mackerel catch origins 1963–64 season.

TABLE 2

Statewide Pacific Mackerel Landings by General Fishing Areas and Seasons

General area	1961–62 Season			1962–63 Season			1963–64 Season		
	Roundhaul	Other	Area	Roundhaul	Other	Area	Roundhaul	Other	Area
	Thousand pounds	*Thousand pounds*	*Percent*	*Thousand pounds*	*Thousand pounds*	*Percent*	*Thousand pounds*	*Thousand pounds*	*Percent*
Central California									
Monterey	10	--	T	1	T	--	--	--	--
Point Sur	4	--	T	--	--	--	--	--	--
Piedras Blancas	21	--	0.1	--	--	--	2	--	T
Southern California									
Santa Monica	2,878	23	7.2	3,663	1	8.9	2,895	2	9.2
San Pedro–Oceanside	5,495	55	13.8	9,031	5	22.0	5,480	31	17.4
San Diego	2,071	27	5.2	1,220	17	3.0	1,183	22	3.8
North Channel Islands and Santa Barbara	8,074	--	20.0	5,282	--	12.9	3,957	1	12.5
San Nicolas Island	4,064	1	10.1	3,151	--	7.7	2,120	--	6.7
Santa Catalina Island	2,411	789	7.9	2,624	31	6.5	4,834	345	16.4
San Clemente Island	6,346	--	15.8	8,687	--	21.1	4,008	1	12.7
Tanner and Cortes Banks	8,010	--	19.9	7,365	--	17.9	6,711	--	21.2
Mexico	--	--	--	--	--	--	--	1	T
Totals	39,384	895	100.0	41,024	54	100.0	31,190	403	99.9
Pounds of Unknown Origin not included above	2,741	1,281	--	3,851	325	--	2,223	395	--
Total Season's Catch	42,125	2,176 *	--	44,875	379 *	--	33,413	798 *	--

* Scoop and striker gear accounted for 95, 92, and 91 percent during the respective seasons.

TABLE 3

Age and Year-class Composition of the Pacific Mackerel Catch in Southern California During 1961–62 Through 1963–64 Seasons

	Number and pounds of fish in thousands by age						
	0	I	II	III	IV	V	Totals
1961–62 Season							
Year-class	1961	1960	1959	1958	1957	1956	
Thousands of fish	24,800	20,391	15,162	7,004	757	117	68,231
Percent	36.3	29.9	22.2	10.3	1.1	0.2	100.0
Thousands of pounds	8,302	14,290	13,215	7,467	859	153	44,286
Percent	18.7	32.3	29.8	16.9	1.9	0.3	99.9
1962–63 Season							
Year-class	1962	1961	1960	1959	1958	1957	
Thousands of fish	8,353	19,637	15,302	6,360	746	--	50,398
Percent	16.6	39.0	30.4	12.6	1.5	--	100.1
Thousands of pounds	5,291	14,948	16,148	7,885	979	--	45,251
Percent	11.7	33.0	35.7	17.4	2.2	--	100.0
1963–64 Season							
Year-class	1963	1962	1961	1960	1959	1958	
Thousands of fish	152	5,752	19,031	5,142	1,599	22	31,698
Percent	0.5	18.1	60.0	16.2	5.0	0.1	99.9
Thousands of pounds	74	5,652	20,333	5,866	2,253	31	34,209
Percent	0.2	16.5	59.4	17.1	6.6	0.1	99.9

TABLE 4

Number of Pacific Mackerel Landed in Southern California by Year-class and Age *

Year-class	Age group 0 *Thousands*	I *Thousands*	II *Thousands*	III *Thousands*	IV *Thousands*	V *Thousands*	Totals *Thousands*
1950	6	1,583	521	583	71	15	2,779
1951	769	46	475	208	204	62	1,764
1952	86	676	3,893	6,021	3,641	2,302	16,619
1953	12,237	40,036	21,156	14,641	8,160	295	96,525
1954	564	3,562	14,976	11,332	1,687	120	32,241
1955	4,237	49,429	30,487	7,300	751	89	92,293
1956	21	6,228	4,533	1,081	134	117	12,114
1957	1,386	1,511	2,692	3,245	757	–	9,591
1958	23,922	30,799	20,104	7,004	746	22	82,597
1959	30,000	21,756	15,162	6,360	1,599	–	74,877
1960	5,100	20,391	15,302	5,142	–	–	45,935
1961	24,800	19,637	19,031	–	–	–	63,468
1962	8,353	5,752	–	–	–	–	14,105
1963	152	–	–	–	–	–	152

* For data prior to the 1950 year-class see Calif. Fish and Game 48(4):226.

TABLE 5

Pounds of Pacific Mackerel Landed in Southern California by Year-class and Age *

Year-class	Age group 0	I	II	III	IV	V	Totals
	Thousand pounds	*Thousand pounds*	*Thousand pounds*	*Thousand pounds*	*Thousand pounds*	*Thousand pounds*	*Thousand pounds*
1950	1	802	474	687	90	24	2,078
1951	252	34	483	234	244	94	1,341
1952	33	463	3,063	6,034	4,394	3,112	17,099
1953	4,358	23,175	16,990	14,973	10,197	411	70,104
1954	94	1,964	11,722	12,294	2,117	191	28,382
1955	1,270	25,940	24,552	8,194	1,026	107	61,089
1956	5	4,222	4,674	1,378	211	153	10,643
1957	466	897	2,455	3,339	859	–	8,016
1958	7,617	18,452	17,299	7,467	979	31	51,845
1959	15,710	16,474	13,215	7,885	2,253	–	55,537
1960	1,503	14,290	16,148	5,866	–	–	37,807
1961	8,302	14,948	20,333	–	–	–	43,583
1962	5,291	5,652	–	–	–	–	10,943
1963	74	–	–	–	–	–	74

* For data prior to the 1950 year-class see Calif. Fish and Game 48(4):226.

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Southern California Pacific mackerel landings during the three reported seasons were dominated by four large year-classes (1958, 1959, 1960, 1961) (Tables 3, 4, 5). Landings increased from 24 million pounds during 1958–59, to 44 and 45 million pounds in 1961–62 and 1962–63 respectively, as these large successive year-classes contributed heavily to the fishery. Landings dropped to 34 million pounds in 1963–64. This decrease was attributed to the decline of the large year-classes, and poor recruitment during 1962 and 1963.

It seems reasonable to conclude that landings during 1964–65 and 1965–66 seasons will be less than 34 million pounds unless at least one, above-average year-class is recruited to replace those which are dwindling.

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APPENDIX A

METHOD FOR ESTIMATING AGE COMPOSITION

The present system for sampling Pacific mackerel was initiated in July 1948. Under this plan, otoliths are removed from the first fish in each 5 quarter-centimeter grouping (106–110, 111–115, etc.) (Fitch, 1951).

Numbers of fish landed are calculated for each month by applying monthly average weights from sample data to the total pounds landed, as reported by he Department's Biostatistical Section. During months of no sampling, the season's weighted average is applied. Total numbers for the season are obtained by summing the monthly landings.

The age composition for each month of sampling is calculated by solving the equation: $N_j = P_j N$ where,

$$P_j = \sum_{i=1}^{L} p_i p_{ij}$$

P_j = Percent of fish j years old, $j = 0 \ldots 5$.

p_i = Percent of fish sampled that are in length interval i, $i = 1 \ldots L$.

p_{ij} = Percent of aged fish at length i that are j years old.

N_j = Number of fish at age j.

N = Number of fish landed.

The size of the length interval, i, is the same as that from which otoliths are selected for age determination.

The relative age composition for the season is obtained by: (i) summing the number of fish landed at each age; and (ii) expressing each sum as a percent of the total numbers landed during the months of sampling. Age composition in numbers, for the season, is determined by applying the relative age composition to the total numbers landed.

The age composition equation and tabled output were programmed and run by David J. Mackett on a UNIVAC 1107.

APPENDIX B

Length Frequency of Pacific Mackerel Sampled During the 1961–62 Season

Fork length cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
1	–	–	–	–	–	–	–	–
2	1	–	–	–	–	–	–	–
3	11	–	–	–	–	–	–	–
4	14	2	–	–	–	–	–	2
75	13	1	–	–	–	–	–	1
6	12	2	–	–	–	–	–	2
7	22	1	–	–	–	–	–	1
8	4	–	–	–	–	–	–	–
9	15	–	–	–	–	–	–	–
80	6	1	–	–	–	–	–	1
1	16	2	–	–	–	–	–	2
2	11	–	–	–	–	–	–	–
3	16	–	–	–	–	–	–	–
4	16	4	–	–	–	–	–	4
85	22	4	–	–	–	–	–	4
6	23	–	–	–	–	–	–	–
7	42	2	–	–	–	–	–	2
8	38	4	–	–	–	–	–	4
9	37	5	–	–	–	–	–	5
90	34	2	–	–	–	–	–	2
1	27	2	–	–	–	–	–	2
2	36	3	1	–	–	–	–	4
3	17	3	–	–	–	–	–	3
4	19	1	–	–	–	–	–	1
95	22	5	1	–	–	–	–	6
6	20	1	–	–	–	–	–	1
7	23	4	1	–	–	–	–	5
8	19	1	1	1	–	–	–	3
9	19	4	1	–	–	–	–	5
100	23	1	2	–	–	–	–	3
1	24	5	–	–	–	–	–	5
2	22	–	1	–	–	–	–	1
3	17	2	1	2	–	–	–	5
4	33	1	5	2	–	–	–	8
105	32	3	5	2	–	–	–	10
6	30	2	1	1	–	–	–	4
7	28	2	5	1	–	–	–	8
8	34	1	7	1	–	–	–	9
9	26	1	4	1	–	–	–	6
110	24	1	4	–	–	–	–	5
1	36	1	6	–	–	–	–	7
2	36	1	2	2	–	–	–	5
3	48	2	2	1	–	1	–	6
4	55	5	7	3	–	–	–	15
115	56	–	7	2	–	–	–	9

APPENDIX B—Continued

Length Frequency of Pacific Mackerel Sampled During the 1961–62 Season

½ cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
6	56	–	1	–	–	–	–	1
7	63	1	7	2	–	–	–	10
8	72	4	7	3	–	–	–	14
9	71	1	2	2	1	–	–	6
120	68	2	3	6	2	–	–	13
1	94	1	5	4	2	–	–	12
2	73	–	6	5	2	–	–	13
3	84	–	3	4	1	–	–	8
4	97	1	1	4	3	–	–	9
125	76	–	–	4	1	–	–	5
6	86	1	1	5	1	–	–	8
7	77	–	6	5	2	–	–	13
8	78	–	2	4	2	–	–	8
9	86	–	1	4	4	–	–	8
130	88	–	2	1	4	–	–	7
1	79	–	1	4	5	–	–	9
2	60	–	2	2	3	1	1	8
3	55	–	1	4	2	1	–	8
4	48	–	1	3	3	1	–	8
135	58	–	3	2	3	–	–	8
6	47	–	1	6	3	1	–	11
7	44	–	3	2	2	–	–	7
8	46	–	–	3	3	3	–	9
9	31	–	1	1	3	1	–	4
140	39	–	–	3	3	–	–	6
1	14	–	–	1	–	–	–	1
2	19	–	–	2	4	1	–	7
3	21	–	–	4	2	1	–	7
4	9	–	–	3	1	1	–	5
145	6	–	–	–	3	–	–	3
6	5	–	–	1	2	1	–	4
7	8	–	1	5	–	–	–	6
8	3	–	–	1	1	–	1	3
9	2	–	–	–	1	1	–	2
150	1	–	–	–	–	1	–	1
1	2	–	–	–	2	–	–	2
2	3	–	–	–	–	–	1	1
3	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–
155	1	–	–	–	1	–	–	1
6	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–
160	–	–	–	–	–	–	–	–
1	1	–	–	1	–	–	–	1
Total	2,850	93	121	119	72	14	3	422

APPENDIX C

Length Frequency of Pacific Mackerel Sampled During the 1962–63 Season

1 cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
1	1	–	–	–	–	–	–	–
2	2	–	–	–	–	–	–	–
3	1	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–
95	4	1	–	–	–	–	–	1
6	1	–	–	–	–	–	–	–
7	3	–	–	–	–	–	–	–
8	4	–	–	–	–	–	–	–
9	3	2	–	–	–	–	–	2
100	2	1	–	–	–	–	–	1
1	2	–	–	–	–	–	–	–
2	5	–	1	–	–	–	–	1
3	6	–	–	–	–	–	–	–
4	4	1	1	–	–	–	–	2
105	4	2	–	–	–	–	–	2
6	8	–	2	–	–	–	–	2
7	9	–	–	–	–	–	–	–
8	9	–	1	–	–	–	–	1
9	9	2	2	–	–	–	–	4
10	12	2	–	–	–	–	–	2
1	20	2	–	–	–	–	–	2
2	25	1	2	–	–	–	–	3
3	40	–	4	–	–	–	–	4
4	47	2	3	–	–	–	–	5
115	34	1	2	1	–	–	–	4
6	53	1	–	–	–	–	–	1
7	51	2	1	1	–	–	–	4
8	57	–	2	1	–	–	–	3
9	47	–	4	2	–	–	–	6
120	51	2	7	1	–	–	–	10
1	58	–	5	1	–	–	–	6
2	49	–	4	2	–	–	–	6
3	44	2	2	3	–	–	–	7
4	49	1	2	–	1	–	–	4
125	53	1	1	3	1	–	–	6
6	50	–	4	2	–	–	–	6
7	52	1	3	1	–	–	–	5
8	38	–	2	2	1	–	–	5
9	32	1	–	3	1	–	–	5
130	38	–	3	2	–	–	–	5
1	24	–	1	–	–	–	–	1
2	44	1	3	2	–	1	–	7
3	36	–	2	2	1	–	–	5
4	42	–	1	3	1	–	–	4
135	47	–	1	4	1	–	–	6
6	40	–	1	4	1	–	–	6
7	34	–	–	2	2	–	–	4
8	38	–	–	3	1	–	–	4
9	28	–	–	2	1	–	–	3
140	36	–	–	1	3	1	–	5

APPENDIX C—Continued

Length Frequency of Pacific Mackerel Sampled During the 1962–63 Season

½ cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
1	37	–	–	5	4	–	–	9
2	29	–	–	3	1	–	–	4
3	14	–	–	2	2	1	–	5
4	21	–	–	1	1	–	–	2
145	14	–	–	–	1	1	–	2
6	14	–	–	3	3	–	–	6
7	7	–	–	2	2	–	–	4
8	5	–	–	1	–	–	–	1
9	11	–	–	3	–	–	–	3
150	1	–	–	–	–	–	–	–
1	2	–	1	1	–	–	–	2
2	1	–	–	–	1	–	–	1
3	2	–	–	–	–	1	–	1
4	2	–	1	–	1	–	–	2
155	3	–	–	–	1	1	–	2
6	–	–	–	–	–	–	–	–
7	1	–	–	1	–	–	–	1
Total	1,500	29	68	70	32	6	–	205

APPENDIX D

Length Frequency of Pacific Mackerel Sampled During the 1963–64 Season

½ cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
90	1	–	–	–	–	–	–	–
1	1	–	–	–	–	–	–	–
2	2	1	–	–	–	–	–	1
3	–	–	–	–	–	–	–	–
4	2	–	–	–	–	–	–	–
95	2	–	–	–	–	–	–	–
6	1	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–
8	2	1	–	–	–	–	–	1
9	1	–	–	–	–	–	–	–
100	–	–	–	–	–	–	–	–
1	1	1	–	–	–	–	–	1
2	1	–	1	–	–	–	–	1
3	–	–	–	–	–	–	–	–
4	1	–	–	–	–	–	–	–
105	–	–	–	–	–	–	–	–
6	4	–	–	–	–	–	–	–
7	4	2	–	–	–	–	–	2
8	1	–	–	–	–	–	–	–
9	2	–	–	–	–	–	–	–
110	3	–	2	–	–	–	–	2
1	4	–	1	–	–	–	–	1
2	2	–	2	–	–	–	–	2
3	7	–	1	–	1	–	–	2
4	11	–	4	1	1	–	–	6
115	8	–	1	–	–	–	–	1

APPENDIX D—Continued

Length Frequency of Pacific Mackerel Sampled During the 1963–64 Season

½ cm	Total sampled	Otoliths read						
		0	I	II	III	IV	V	Total
6	17	–	3	2	–	–	–	5
7	8	–	–	–	–	–	–	–
8	15	–	1	–	–	–	–	1
9	12	–	1	4	–	–	–	5
120	19	–	1	3	–	–	–	4
1	22	–	–	4	–	–	–	4
2	26	–	1	2	–	–	–	3
3	31	–	1	4	–	–	–	5
4	35	–	1	1	–	–	–	2
125	37	–	3	4	1	–	–	8
6	49	–	1	1	1	–	–	3
7	49	–	3	4	–	–	–	7
8	50	–	3	2	1	–	–	6
9	65	1	3	3	2	–	–	9
130	66	–	1	2	1	–	–	4
1	69	–	2	5	–	–	–	7
2	63	–	1	2	2	–	–	5
3	71	–	1	5	–	–	–	6
4	75	–	1	4	–	–	–	5
135	69	–	2	2	2	–	–	6
6	58	–	–	1	–	–	–	1
7	63	–	1	8	4	–	–	13
8	57	–	–	3	–	1	–	4
9	62	–	–	3	3	–	–	6
140	55	–	–	5	2	–	–	7
1	44	–	–	3	4	1	–	8
2	51	–	–	3	4	3	–	10
3	39	–	–	1	1	–	–	2
4	36	–	–	2	1	–	–	3
145	40	–	1	–	1	–	–	2
6	35	–	–	2	2	2	1	7
7	30	–	1	3	1	–	–	5
8	22	–	–	1	1	1	–	3
9	10	–	–	1	–	1	–	2
150	5	–	–	–	–	–	–	–
1	6	–	–	–	3	1	–	4
2	9	–	–	–	3	2	1	6
3	8	–	–	–	–	1	–	1
4	4	–	–	1	–	1	–	2
155	5	–	–	–	2	–	–	2
6	1	–	–	–	1	–	–	1
7	1	–	–	1	–	–	–	1
Total	1,550	6	45	93	45	14	2	205

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RECORDS OF YELLOW AND SPOTTED SNAKE-EELS (GENUS *OPHICHTHUS*) FROM SAN FRANCISCO BAY, CALIFORNIA[1]

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A northern range extension of approximately 400 miles, description, and illustration of the yellow snake-eel, *Ophichthus zophochir* (Jordan and Gilbert), is presented from a specimen 647 mm *TL* collected in April, 1964, from San Francisco Bay. Recent records indicate the yellow snake-eel is rather common in southern California waters. The spotted snake-eel, *Ophichthus triserialis* (Kaup), is recorded from San Francisco Bay on the basis of three specimens collected on three separate occasions.

A yellow snake-eel, brought to the University of California for identification by Joseph Tiner of Oakland, was caught by an unidentified fisherman with hook and line from Berkeley Pier, Alameda County, California, on April 16, 1964. It extends the northern geographical limits of the species by approximately 400 miles. Previous records for California have all been based upon specimens from southern California (Hubbs, 1916: 154; Fowler, 1923: 287, 296; Radovich, 1961: 22; Outdoor California, 1962: 14). The species is known as far south as Panama (Jordan and Gilbert, 1883: 632; Gilbert and Starks, 1904: 37).

The occurrence of the yellow snake-eel in southern California in 1957, along with many other tropical species of fishes, indicated to Radovich (1961) a warm period for the northeast Pacific Ocean. Recent records from southern California now indicate this species is not as rare as previously believed. Since 1953, the California State Fisheries Laboratory on Terminal Island has received seven yellow snake-eels:

1) 4 March 1953, Long Beach Harbor, seaward side of Pier A, caught in a suction dredge in 30 feet of water, Frank Luciene coll. (822 mm TL; size record for the species, *see* Outdoor California, 1962);
2) 11 December 1957, Santa Monica Bay in a lampara net by boat *Josie Lena* (645 mm TL);
3) 28 May 1961, Alamitos Bay, hook and line, Edward Ramsey coll. (720 mm TL, 405 grams);
4) 21 June 1961, Pierpoint Landing, Long Beach, hook and line by a small boy, saved by J. E. McClintock (580 mm TL, 245 grams);
5) 29 June 1961, San Clemente Pier, hook and line, William Martens coll. (510 mm TL, 155 grams);
6) 13 January 1962, Alamitos Bay, hook and line using squid for bait, piece of clam in stomach, James Ryan coll. (585 mm TL, 260 grams);
7) 30 June 1962, Belmont Shore Pier, hook and line using cut sardine, saved by Leo Pinkas (625 mm TL).

[1] Submitted for publication January 1965.

Some of these eels were mentioned and one illustrated in *Outdoor California* (1962). Specimens were deposited in the collections of either the University of California at Los Angeles or the Los Angeles County Museum. During June 1962, as many as three to five yellow snake-eels per week were caught from Belmont Shore Pier, Long Beach. This "minor fishery," reported by Biologist Leo Pinkas while conducting a pier fishery survey, lasted for perhaps 5 or 6 weeks (John E. Fitch, pers. commun.). Jordan and Gilbert (1882: 385) claimed the yellow snake-eel to be "rather common in the rocks about Mazatlan" on the western coast of Mexico.

The spotted snake-eel, *Ophichthus triserialis* (Kaup), is the only other member of the genus known from California. This species can be distinguished from the yellow snake-eel by the large, black spots on its body and its uniserial vomerine teeth. The yellow snake-eel completely lacks spots on the body and possesses biserial vomerine teeth. Both species possess biserial jaw teeth (note error in the description of *O. triserialis* on p. 384 of Jordan and Evermann, 1896). The range of the spotted snake-eel is from the Galapagos Islands (Jordan and Evermann, 1896) north to Tomales Bay (Hubbs, 1916: 153). A spotted snake-eel in the collections of the California Academy of Sciences (CAS 12649), ca. 1060 mm TL and 667 grams after preservation, is labelled "coast of Northern California" and was collected by C. Kofoid in September 1930.

Records of the spotted snake-eel from San Francisco Bay are as follows: CAS 11062 (presently in the collections of the University of California at Los Angeles) : 1 skeleton, Tiburon near Richardson's Bay, Marin County, no date of collection, Thomas Foley; CAS 19770: 1, ca. 1040 mm TL and 1191 grams after preservation, Black Point, Marin County, September 14, 1931, gift of J. M. Harrity; CAS 23715: 1, 886 mm TL and 744 grams after preservation, Point San Quentin, Marin County, May 15, 1948, caught by Robert W. Johnston with hook and line (sardine bait).

The preceding records for yellow and spotted snake-eels indicate that all three species of snake-eels known for the state of California occur in San Francisco Bay. Harry (1948:145) recorded the tiger snake-eel, *Myrichthys tigrinus* Girard, from San Francisco Bay.

The present specimen of yellow snake-eel is deposited at the California Academy of Sciences (CAS 23683). Color before preservation in formalin was maroon above and yellowish-brown to yellow below. Dorsal and anal fin margins were edged with black. After preservation, dorsum appeared brown and venter brownish-white. Lateral line pores were rimmed with black, slightly darker than the background color. Snout, lower jaw, gular, and cheek regions also were tinged with black. Throat region was white, much lighter than remainder of body.

Total length was 647 mm (644.5 mm SL) and weight 265 grams after preservation. Body measurements, expressed in thousandths of total length, are as follows: head length (to upper edge of gill opening) 089; head depth (in throat region) 038; snout length 014; orbit length 008; least interorbital distance 012; upper jaw length (from snout to rictal commissure) 030; snout tip to tip of lower jaw 004; dorsal fin base 861; dorsal origin to snout 132; dorsal origin to pectoral

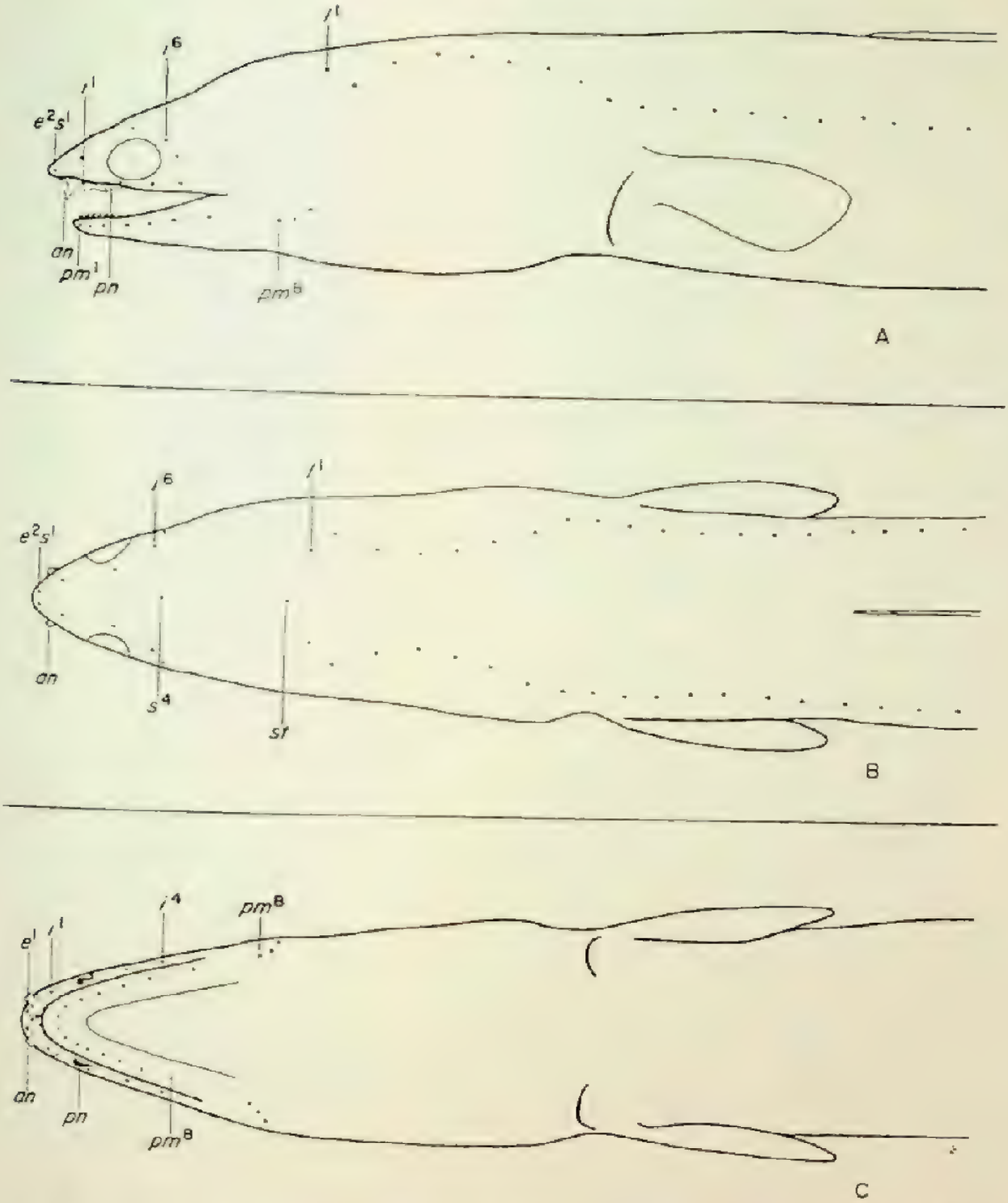

FIGURE 1. Distribution of sensory pores on the head of *Ophichthus zophochir* in (A) lateral, (B) dorsal, and (C) ventral view. Symbols: *an*, anterior nostril; *pn*, posterior nostril; *st*, supratemporal pore; l^1, first lateral line pore; i^1, first infraorbital pore; e^1, first ethmoidal pore; e^2s^1, compound pore formed from second ethmoidal and first supraorbital pores; pm^1, first preoperculomandibular pore. Terminology after Allis, 1903, and Kanazawa, 1963. *Drawings by the author.*

origin 046; dorsal origin to anal origin 251; post-dorsal distance 009; greatest body depth (region between pectoral origin and anal origin) 043; pectoral origin to snout 093; and fin base 615; anal origin to snout 376; post-anal distance 009; height of gill opening 013.

Lateral line pores 148 (149 on right side): 51(51) before anal origin and 97(98) behind anal origin; supratemporal pore 1; preopercule-mandibular pores 10(11); 3(3) preopercular and 7(8) mandibular; supraorbital pores (including ethmoidal) 4(4); infraorbital pores 6(6) (Figure 1).

Vertebrae 153; 46 precaudal and 107 caudal; pectoral fin rays 16(16).

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TROUT CATCH AND ANGLER USE AT LAKE TAHOE IN 1962[1]

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Estimates of total use and catch were obtained by a joint California and Nevada creel census by boat, and at Cave Rock boat landing. Angler-hours and catches on censused days were expanded to monthly totals. Possible biases were examined and considered unimportant, although an underestimate of use and catch was indicated. Total use was 144,147 angler-hours (47,732 angler-days); this amounted to 1.2 angler-hours per surface acre. The total catch was 20,018 fish, or 0.14 fish per angler-hour. About 60 percent of the catch was lake trout, with "wild" rainbow and planted trout comprising 21 and 17 percent, respectively. Estimated yield, excluding planted trout, was 0.34 pounds per acre.

INTRODUCTION

Scope

The California Department of Fish and Game and the Nevada Fish and Game Commission initiated a joint study of Lake Tahoe on July 1, 1960. The basic objective was to find and test methods of improving trout fishing.

Creel censusing was one of the important tools used in this study. The specific purposes of the census were: (i) to provide a quantitative description of the sport fishery; (ii) to establish a baseline of existing conditions so that future changes can be recognized and evaluated; (iii) to evaluate experimental trout plants, and (iv) to obtain biological data from angler-caught fish.

This report presents estimates of total catch, total use, and angler origin for 1962 and describes methods, assumptions, and limitations of the data. Later reports will present results for the remaining years of the census, plus additional aspects of the fishery including the success of various trout stocking practices.

Background Information

Lake Tahoe is a 123,300-acre oligotrophic lake in the Sierra Nevada of California and Nevada (Figure 1). Its basin is a down-faulted trough formed in the late Tertiary. It has steep sides, a flat bottom, and a relatively small littoral zone. The average depth is 1,027 feet, and the maximum depth 1,645 feet (McGauhey *et al.*, 1963, p. 58).

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[2] Now with Water Projects Branch, California Department of Fish and Game.

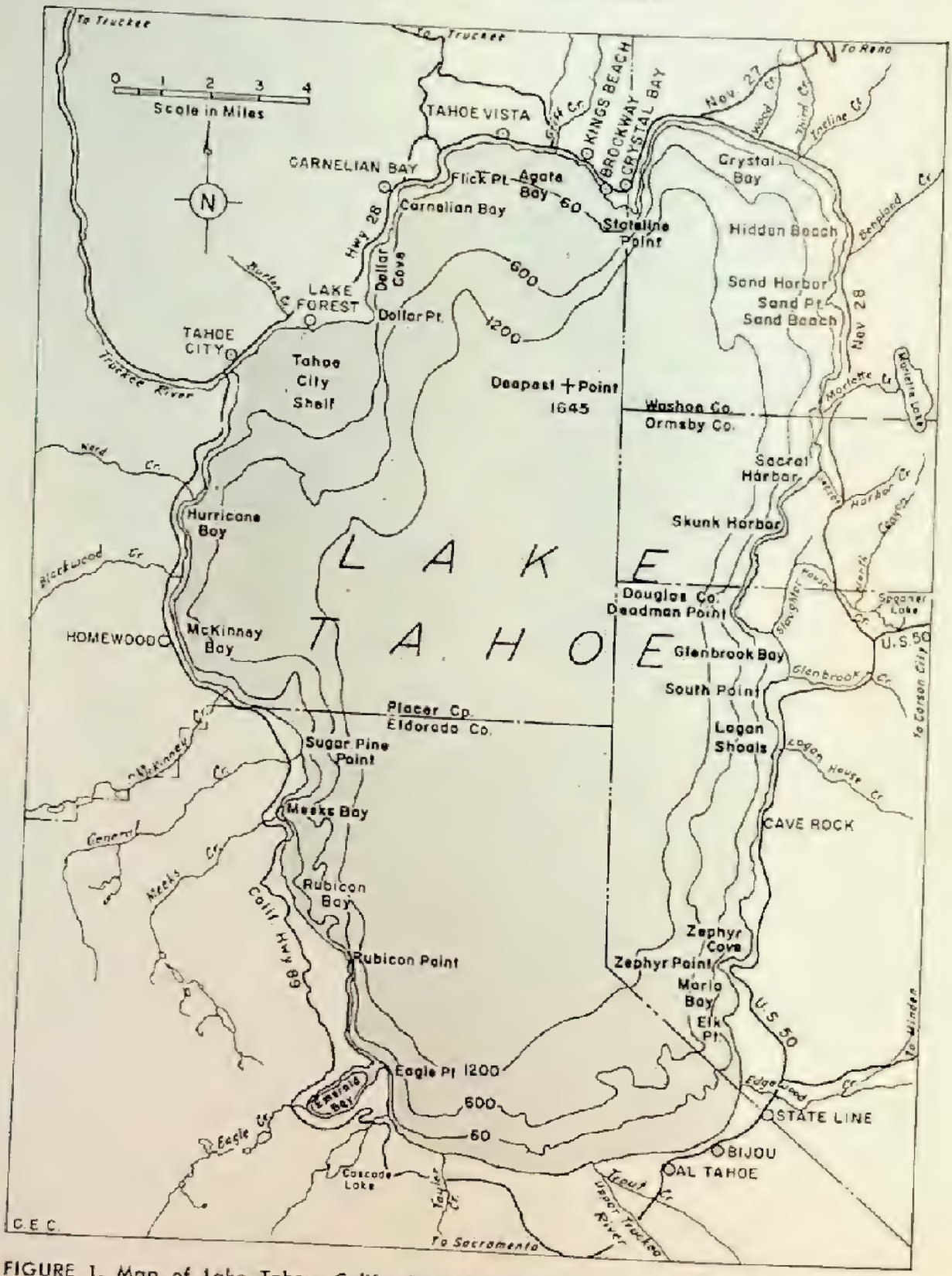

FIGURE 1. Map of Lake Tahoe, California and Nevada, showing important landmarks. *Map drawn by Cliffo E. Corson.*

Tahoe is approximately 12 miles wide and 22½ miles long, with a perimeter of 71½ miles. It is somewhat oval, has relatively few shoreline irregularities, and contains 126,500,000 acre-feet of water. A small dam controls the upper 6.1 feet of Tahoe, but the average an-

nual fluctuation is only about 2½ feet. Tributaries are numerous but small. The watershed covers about 506 square miles (314 are land, and 192 are Tahoe itself).

Water temperatures are cold, generally in the low 40's (degrees F.) in winter and in the mid-60's at the surface in summer. Dissolved oxygen is always near saturation at all depths. Transparency is high with Secchi disk readings usually between 75 and 100 feet. Dissolved solids are low, generally between 60 and 65 ppm, and are mostly bicarbonates. Hydrogen ion concentration usually varies between 7.5 and 8.0.

Lake Tahoe once supported a sizeable sport and commercial fishery for Lahontan cutthroat trout (*Salmo clarkii henshawi*). Juday (1907) presented data which suggest that commercial catches approached 75,000 pounds in good years. Since the extinction of this species during the 1930's, anglers have been generally dissatisfied with fishing despite the establishment of several exotic game species and other management efforts.

The fishery is now dependent on lake trout (*Salvelinus namaycush*) and wild and planted rainbow trout (*Salmo gairdneri*). Smaller numbers of brown trout (*Salmo trutta*) and mountain whitefish (*Coregonus williamsoni*) are caught, as are a few eastern brook trout (*Salvelinus fontinalis*) and kokanee salmon (*Oncorhynchus nerka*).

ACKNOWLEDGMENTS

We are indebted, first of all, to the numerous Tahoe anglers who cooperated wholeheartedly with our census. We thank Herbert Obexer of Obexer's Boat and Motor Sales for furnishing winter mooring for the census boats. In many other ways, the cooperation of boat-dock owners and operators around the lake contributed substantially to our success. On most days, the creel census was conducted by temporary employees. The sustained high quality of their work supplied the raw data upon which this report is based. We are grateful to Alex Calhoun, Chief of Inland Fisheries, California; Harold K. Chadwick, Research Supervisor of Inland Fisheries, California; and Thomas J. Trelease, Chief of Fisheries, Nevada, for their support, encouragement, and editorial suggestions. The 1962 raw data were tabulated by the Biostatistical Section, Marine Resources Operations, California Department of Fish and Game. In all of our activities, members of the South Tahoe Rod and Gun Club have been particularly helpful.

FIELD PROCEDURES

Tahoe's large size and numerous angler access points precluded a complete census of anglers, so an indirect approach was necessary to obtain estimates of total catch and angler use. This was done by taking two separate, but coordinated, year around creel censuses. The first was a check station census at the Cave Rock Public Boat Landing, where anglers were checked after they had completed fishing for the day. The second was a boat census [3] covering the entire perimeter of the lake. Most anglers censused by boat were contacted before they completed fishing.

[3] For this report the term "boat census" refers to the method of contacting anglers. It does not refer to a census of anglers fishing from boats ("boat anglers").

FIGURE 2. Cave Rock Public Boat Landing, Douglas County, Nevada. *Photograph by Ted C. Frantz, September 1961.*

Catch statistics were stratified by lake area and angler category.[4] However most of the data presented in this paper combine all lake areas, and also all angler categories.

Cave Rock Creel Census

Cave Rock Public Boat Landing is a popular launching site for boat anglers and also a popular shore fishing spot (Figure 2). It is on the east shore of Lake Tahoe adjacent to U.S. Highway 50, and was the only sizeable public launching facility available to anglers in 1962. There are no piers at this site.

The Nevada Fish and Game Commission has conducted a creel census at Cave Rock since 1958. During 1962, censusing was conducted on one weekday and one weekend day each week. Weekdays were selected systematically with Monday being sampled the first week, Tuesday the following week, etc. Weekend days were simply alternated, with Saturday sampled one week and Sunday the next. All holidays, generally considered important fishing days, were sampled. Each scheduled census day was sampled regardless of the weather.

The census day normally began between 9 and 10 AM during the colder months, when few anglers get out early, but during the summer the census started earlier (Table 1). The census continued until the last boat or shore angler departed. If no anglers were present, the census ceased at 5 PM during the winter months, and at sunset during the remaining months.

[4] Angler categories were: pier fishing, shore fishing, "toplining," and "deeplining." All boat anglers using metallic line of any type were considered deepliners. Boat anglers using non-metallic lines were termed topliners.

TABLE 1

Creel Census Starting Times at Cave Rock Boat Landing for 1962 *

Starting time, AM	Jan.	Feb.	March	April	May	June	July †	Aug.	Sept.	Oct.	Nov.	Dec.
Earliest	9:00	9:15	9:20	8:55	8:45	8:45	4:40	5:30	7:45	8:55	8:45	9:00
Average	9:45	9:35	10:15	9:40	9:15	9:05	5:35	6:35	8:30	9:00	9:00	9:05
Latest ‡	11:30	10:30	11:30	10:35	9:55	9:30	6:00	7:00	9:05	9:05	9:10	9:10

* Pacific standard time and daylight saving time where appropriate.
† Does not include two starting times of 9:00 and 8:45 A.M.
‡ Most late starting times were on very stormy days when anglers also began their fishing effort later.

Catch statistics obtained from each angler included fishing method, number of fishing hours (to the nearest ¼ hour), number of fish caught by species, and the name of the angler's home town. Biological information was also collected for other purposes and will be presented in later reports.

Boat Census

The California Department of Fish and Game began a comprehensive creel census in September 1960. During 1962, this census was conducted from two boats, except for days when one boat was inoperable, or when weather conditions made a census trip unsafe. The census usually started from different locations between 9 and 9:30 AM, and moved counterclockwise along the shore. Each boat made a complete trip around the lake. All anglers encountered were interviewed, weather permitting. By traveling close to shore, it was possible to census all boat anglers, as well as pier and shore anglers.[5] When anglers were checked a second time, information was taken only for the elapsed time since the first contact. Caudal fins were clipped to identify fish examined previously.

The boat census usually terminated about 3 PM in fall and winter when angler use was very low, and between 6 PM and dark in spring and summer when angler use was high.

Census boats started at opposite sides of the lake, so they were generally one-half the lake's perimeter, and about 3 to 4 hours apart. Boat-to-boat radio communication helped to maintain this separation. Starting points were established at shoreline locations on the northwest (Dollar Point), the southeast (Elk Point), the west (Sugar Pine Point), and the east (Deadman Point). The boats alternated between the opposite pairs of starting points to reduce biases which might result from habitually sampling the same lake area at the same time of day.

Boat census days were selected much like Cave Rock census days, except different days were selected to avoid interviewing individual anglers too many times. The boat census schedule was changed occasionally when rough water made censusing unsafe. The census was then rescheduled for the same day the following week. This occasionally set the boat and Cave Rock censuses on the same day. Days which could not be rescheduled before the end of the month were skipped.

Boat census statistics were similar to those obtained at Cave Rock, but anglers using the Cave Rock facilities were tallied separately. Also, anglers who were actively fishing were tallied separately from those who were not. When anglers could not be approached safely because

[5] Because of fish distribution, most fishing is restricted to a relatively narrow zone around the lake's perimeter. The Tahoe City shelf area is the prime exception. There anglers fish as far as 2½ miles from shore. Binoculars were used to locate boat anglers in such areas.

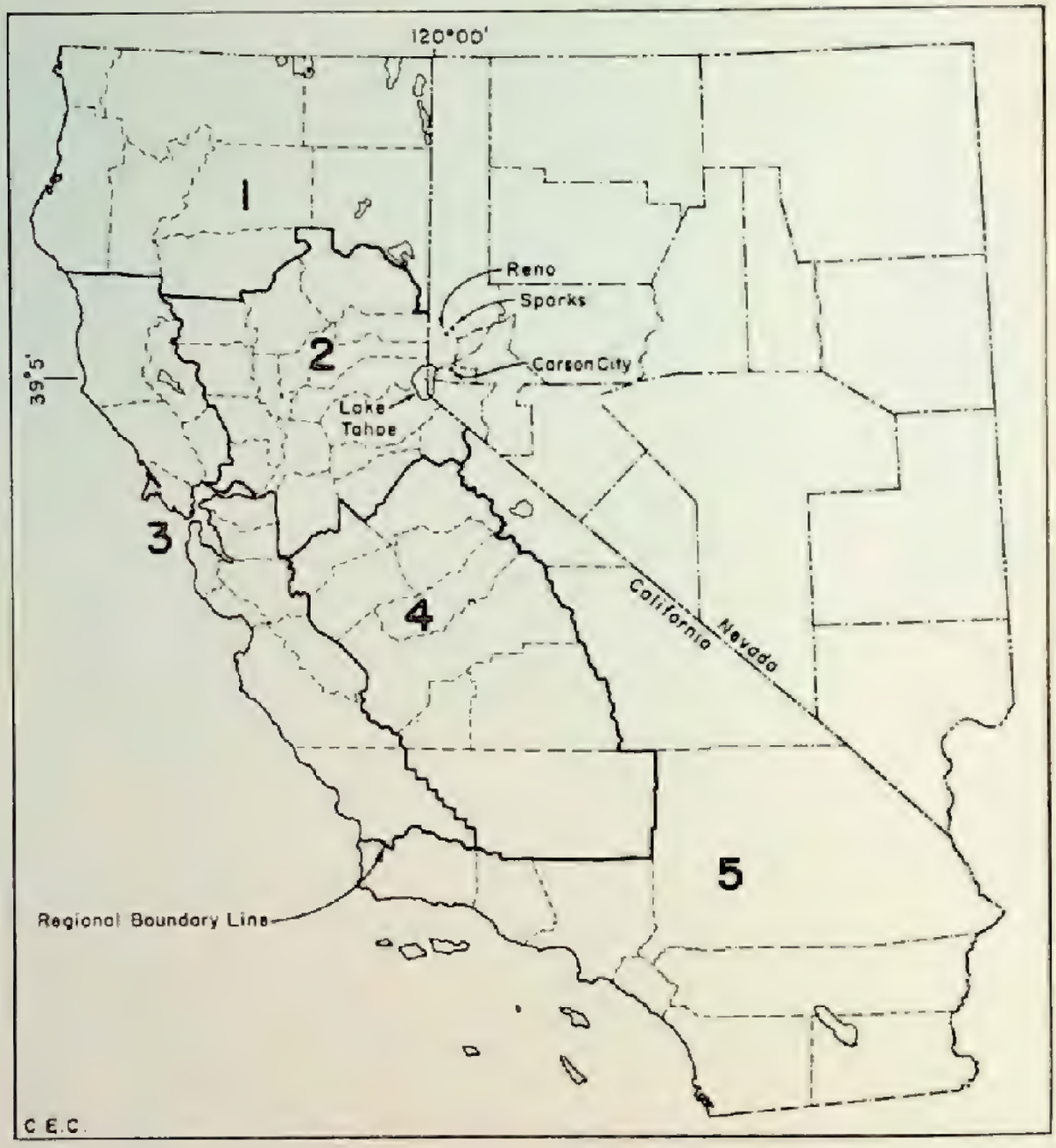

FIGURE 3. Map of California and Nevada showing angler origin localities. Map drawn by Cliffa E. Corson.

of rough or very shallow water, they were only counted, and their fishing method noted.

Each angler was asked his home town, and was thereby assigned to 1 of 11 different areas of origin. In California, these were the five Department of Fish and Game Regions, plus the area within 5 miles of Lake Tahoe (Figure 3). In Nevada, the origin areas were: (i) areas within 5 miles of the lake, (ii) Reno and Sparks, (iii) Carson City, and (iv) other areas. The final category was used for other states and nations.

METHODS OF ANALYSIS

Average total angler-hours per day for weekday and weekend day strata were calculated monthly for Cave Rock anglers. These averages, multiplied by total days in the strata, plus the observed holiday angler-

TABLE 2

Cave Rock Total Angler-Hour Estimates for 1962

Month	Weekdays			Weekend days			Holidays*	Estimated total Cave Rock angler hours
	Number of days in month	Average total angler-hours per day censused	Estimated total angler-hours for month	Number of days in month	Average total angler-hours per day censused	Estimated total angler-hours for month	Total holiday angler-hours censused	
January	22	13.4	294.8	8	30.5	244.0	42.8	581.6
February	19	11.8	224.2	9	24.4	219.6	--	443.8
March	22	14.8	325.6	9	40.1	360.9	—	686.5
April	21	52.9	1,110.9	8	142.8	1,142.4	153.5	2,406.8
May	22	27.8	611.6	8	63.0	504.0	194.8	1,310.4
June	21	84.4	1,772.4	9	167.7	1,509.3	—	3,281.7
July	21	80.6	1,692.6	9	180.8	1,627.2	206.0	3,525.8
August	23	75.3	1,731.9	8	108.5	868.0	—	2,599.9
September	19	15.8	300.2	10	80.3	803.0	70.5	1,173.7
October	23	6.2	142.6	8	53.8	430.4	—	573.0
November	22	2.6	57.2	8	59.1	472.8	—	530.0
December	21	51.8	1,087.8	10	89.0	890.0	—	1,977.8
						Total Cave Rock angler-hours for 1962 =		19,091.0

* Reading from top to bottom the holidays are New Year's Day, Easter, Memorial Day, Independence Day, and Labor Day

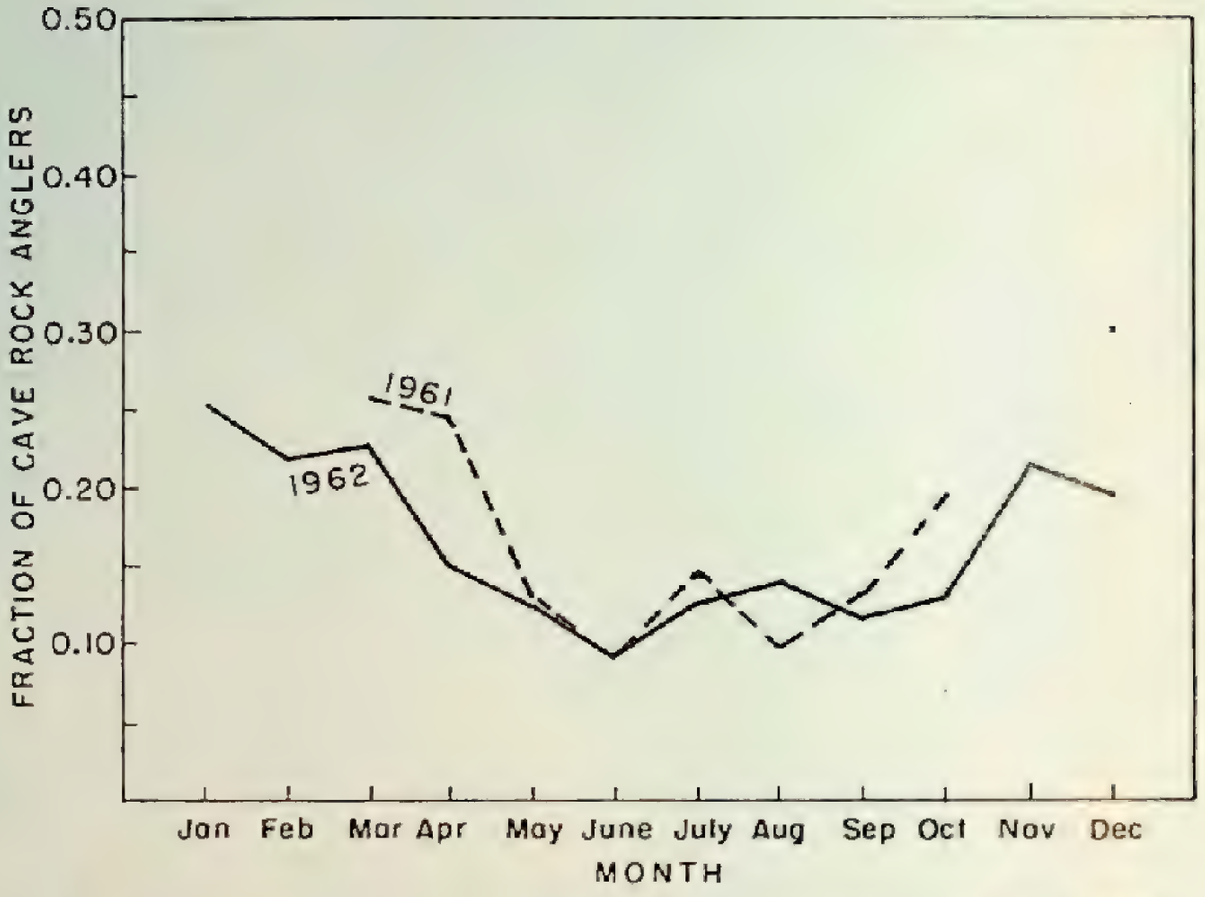

FIGURE 4. Fraction of Cave Rock anglers checked during boat census for 1961 and 1962. No observations for January, February, or November 1961. *Figure drawn by Cliffa E. Corson.*

hours, yielded estimates of total monthly Cave Rock angler-hours (Table 2). Holidays not sampled were assigned to the appropriate weekday or weekend day strata.

The fraction of total lakewide anglers originating at Cave Rock was estimated from the boat census. This relationship of Cave Rock use to total lake use was expressed as a decimal fraction, and is referred to as "fraction of Cave Rock anglers." Only data from completed boat census trips and from anglers who are actively fishing were used in this estimate.

The fraction of Cave Rock anglers was estimated for each month in 1962, and most months in 1961 (Figure 4). In 1962, the fraction ranged from about 0.09 to 0.15 from April through October, and from about 0.19 to 0.25 in other months. The fraction increases in winter because the Cave Rock Landing is generally kept free of snow, while many other access areas are closed.

The monthly 1961 and 1962 fractions are similar, suggesting that the ratio of Cave Rock anglers to total Tahoe anglers may be quite constant during any given month of the year.

Total Tahoe angler-hours were estimated for each month from the equation:

$$\frac{\text{Total Cave Rock angler-hours}}{\text{Total Tahoe angler-hours}} = \frac{\text{Cave Rock anglers counted}}{\text{Tahoe anglers counted}}$$

Since the righthand side of the equation is the fraction of Cave Rock anglers, the equation becomes:

$$\text{Total Tahoe angler-hours} = \frac{\text{Total Cave Rock angler-hours}}{\text{Fraction of Cave Rock anglers}}$$

Monthly estimates of total angler-hours were multiplied by the monthly lakewide catch per hour for each species to estimate total catches of each species.

Monthly total angler-days from each area of origin were estimated by dividing monthly angler-hour estimates for each angler category by the monthly average length of the angler-day for the corresponding angler category at Cave Rock. We assumed the average angler-day for each category in the entire lake was equal to that at Cave Rock. Since the Cave Rock Landing has no piers, we also assumed that the average day for pier anglers was equal to that for Cave Rock shore anglers.

All the estimated totals are point estimates. There is no way to derive confidence limits for them. The following discussion of bias may provide a judgment indication of confidence.

POSSIBLE BIASES

During 1962, we sampled 13.8 percent of the estimated total angler-hours. Our boat census checked 8.9 percent of the estimated total hours for the entire lake, and at Cave Rock we sampled 37.2 percent of the estimated total hours originating from that landing. Because of these relatively low sampling levels, biases in sampling are important considerations.

We noted that angling tended to start earlier in the summer than in the winter. The Cave Rock census starting times reflect this. However, if significant numbers of anglers left the landing before the start of the census, a bias would be introduced, because we assumed that all of the Cave Rock angler effort was censused. Early morning censuses were made during July 1962, to evaluate the error which would have been caused if the census began at 9:30 AM. We found that 5.2 percent of all angler efforts were completed before 9:30 AM and that 2.9 percent of total fishing hours were completed by 9:30.[6] This would cause a slight underestimate of total angler use at Cave Rock and thus, the use estimate for the entire lake. Since this bias would be even less important in months with less daylight and poorer weather, and since we incorporated all early censuses in our estimates, we did not attempt to correct this source of bias.

[6] For topliners the corresponding percentages were 10.8 and 5.0, and for shore anglers 4.6 and 3.6 No deepliners completed fishing before 9:30 AM. Actually, these percentages are overestimates because some anglers who completed fishing before 9:30 AM did not leave immediately and would have been contacted by a census clerk arriving then (boat anglers would tend to have the greatest overestimate).

Some boat census estimates may be biased because the boat census was conducted during only part of the legal angling day. Since it was not possible to evaluate this bias properly, we had to assume that (i) the catch per hour obtained from the central portion of the day was an unbiased estimate of the whole day's catch per hour and (ii) the fraction of all anglers originating from Cave Rock was an unbiased estimate of the whole day's fraction. We believe the latter assumption may not be fully justified, since early- and late-fishing anglers probably tend to fish close to their lodging, and the Cave Rock Landing is not close to popular summer camping areas. Our observations indicate that few Tahoe anglers fish early in the morning. However, evening pier fishing in the summer is popular on the California side and commonly lasts after dark (legal fishing is from 1 hour before sunrise to 2 hours after sunset). Missing these anglers causes an underestimate of lakewide use and catch. Although substantiating data are lacking, we believe the error is small.

The fraction of Cave Rock anglers would be useful for estimating total use only if it is not correlated with factors affecting the sampling. Since the boat census was not conducted during inclement weather, the percentages of Cave Rock anglers from individual days were plotted against wind velocity, or direction, or both, at the South Tahoe Airport to see if weather affected the fraction. This gave no indication of any relationship within the range of weather conditions that permitted the boat census. We therefore assumed that the fraction was not influenced on days with weather too inclement for the boat census.

Another bias might be introduced by including data from days when only one boat could make a complete trip around the lake. Comparison of the fractions obtained from one- versus two-boat censuses revealed no consistent differences. The only difference was that two-boat censuses sampled more anglers and therefore the fraction obtained from these days was less variable.

The final possible source of bias examined was the variation between the fraction of Cave Rock anglers on weekend days as opposed to weekdays. Again, no differences were indicated.

In summary, we found no biases which would preclude the use of our methods, but the biases we did find would cause use and catch to be underestimated.

RESULTS AND DISCUSSION

Total Angler Use

Total 1962 Lake Tahoe angler use was estimated to be 144,147 angler-hours (47,732 angler-days). Greatest use occurred from April through September, with a peak of 35,671 hours in June (12,097 angler-days) (Table 3). Use during other months was much reduced, except for December. The high use in December was no doubt a function of good weather and holidays (even in midwinter, angler use increases substantially during periods of clear, calm weather). Use was divided fairly evenly among various fishing methods with 39,046 deepline, 42,931 topline, 27,752 shore, and 34,422 pier angler-hours. Corresponding angler-day figures are 8,404, 12,060, 12,170, and 15,098, respec-

tively. Seasonal patterns of use by the four fishing methods were similar except for more pronounced peaking of shore and pier fishing in summer.

TABLE 3

Total Lake Tahoe Angler Use Estimates for 1962

Month	*Total Cave Rock angler-hours*	*Fraction of Cave Rock anglers*	*Total Tahoe angler-hours*	*Total Tahoe angler-days*
January	581.6	0.251	2,317	890
February	443.8	0.217	2,045	932
March	686.5	0.227	3,024	1,051
April	2,406.8	0.149	16,153	6,221
May	1,310.4	0.122	10,741	3,392
June	3,281.7	0.092	35,671	12,097
July	3,525.8	0.124	28,434	9,585
August	2,599.9	0.140	18,571	5,814
September	1,173.7	0.116	10,118	2,723
October	573.0	0.129	4,442	1,464
November	530.0	0.213	2,488	639
December	1,977.8	0.195	10,143	2,924
Totals	19,091.0		144,147	47,732

Angler use is often expressed in terms of annual angler-hours per surface acre. At Tahoe, this was 1.2, which is extremely low. Unpublished results from an intensive netting program indicate that game fish occur principally in relatively shallow water (less than half of the lake bottom), and angler use is even more restricted. Angler densities based on the areas actually used by fish and fishermen might give a more meaningful comparison with other waters. However, since energy cycles in all parts of the lake are interrelated, we did not attempt computations on a reduced acreage basis.

Catch Per Hour and Total Catch

Lakewide catches per hour were estimated for all fishing methods combined for each month during 1962 (Table 4). These catches per hour are useful for estimating total catches. They do not reflect angling quality for an individual method, since method largely controls success for each species. Only the combined data are presented in this report, since we are concerned primarily with total use and catch.

Catch per hour estimates were multiplied by total monthly angler-hours to estimate total catches (Table 5). About 60 percent of the estimated 1962 catch was lake trout. "Wild" rainbow trout[7] and planted trout comprised about 21 and 17 percent of the catch, respectively. Brown trout, whitefish, and eastern brook trout consituted the other 2 percent. The wild trout catch composition was about 72 percent lake trout, and 25 percent rainbow trout. The planted trout category includes a variety of strains and species. Evaluation of the planted trout returns requires extensive analysis, and will be treated in a separate report.

[7] All unmarked rainbow trout were assumed to be "wild" or naturally-reproduced trout even though a few could have been unmarked, planted trout. All yearling trout released in 1962 were marked, and over 90 percent of those released in 1960 and 1961 were marked. Since few of these yearling trout are caught or survive after a year of liberty, error from this source was certainly small. Many unmarked fingerlings were planted prior to 1960, but their survival is believed to be low, although supporting evidence is lacking.

TABLE 4

Lake Tahoe Catch Per Hour Estimates by Species, All Fishing Methods Combined for 1962 *

Species	*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*All months*
Lake trout	0.111	0.130	0.134	0.102	0.141	0.090	0.045	0.033	0.067	0.102	0.114	0.134	0.085
Wild rainbow trout †	0.037	0.018	0.017	0.027	0.026	0.026	0.032	0.020	0.027	0.044	0.062	0.040	0.029
Planted trout ‡	0.006	0.007	0.004	0.011	0.004	0.015	0.024	0.071	0.005	0.020	0.062	0.027	0.022
Brown trout	0.006	0.004	0.002	0.005	0.005	0.001	0.002	--	--	0.003	--	--	0.002
Mountain whitefish	--	--	--	0.011	0.005	--	0.000	--	--	--	0.014	0.002	0.002
Eastern brook trout	--	--	--	--	--	--	--	--	--	--	0.002	--	--
All species	0.159	0.158	0.157	0.156	0.181	0.132	0.103	0.123	0.099	0.169	0.254	0.203	0.141

* Blanks indicate no fish in creel census. Zero catch per hour indicates fish in creel census, but catch per hour rounded off to 0.000.
† May include a small percentage of unmarked, planted trout (see footnote 7).
‡ Includes various strains and species of rainbow, cutthroat, and brown trout.

TABLE 5

Lake Tahoe Total-Catch Estimates for 1962

Month	*Lake trout*	*Wild * rainbow trout*	*Planted trout*	*Brown trout*	*Mountain whitefish*	*Eastern brook trout*	*All species*
Month	*Lake trout*	*Wild * rainbow trout*	*Planted trout*	*Brown trout*	*Mountain whitefish*	*Eastern brook trout*	*All species*
January	257	86	14	14	0	0	371
February	266	37	14	8	0	0	325
March	405	51	12	6	0	0	474
April	1,648	436	178	81	178	0	2,521
May	1,514	279	43	54	54	0	1,944
June	3,210	927	535	36	0	0	4,708
July	1,280	910	682	57	0	0	2,929
August	613	371	1,319	0	0	0	2,303
September	678	273	51	0	0	0	1,002
October	453	195	89	13	0	0	750
November	284	154	154	0	35	5	632
December	1,359	466	274	0	20	0	2,059
All months	11,967	4,125	3,365	269	287	5	20,018
Percentage of total	59.8	20.6	16.8	1.3	1.4	0.0	99.9

* May include a small percentage of unmarked planted trout (see footnote 7).

Yield Per Surface Acre

Pounds yielded per surface acre were estimated for major game fish species. Total weight in pounds was obtained by multiplying total catch in numbers by average weight of each species in the catch. Pounds per surface acre were then derived by dividing total weights by total lake area. Planted trout were not included in the yield estimates, since many were planted at catchable size and caught shortly thereafter. In 1962, on a lakewide basis, Tahoe yielded 0.28 pounds per acre of lake trout, 0.05 pounds of rainbow trout, and 0.01 pounds of brown trout for a grand total of about 0.34 pounds per acre. Thus, on a poundage basis, lake trout were even more important than on a numerical basis, constituting about 82 percent of the yield.

Yield estimates, based on Tahoe's total surface area, have limited meaning, since the various species do not utilize the whole lake. This cannot be overcome entirely because of the interrelation of the energy cycles in all parts of the lake. As mentioned previously, net sampling indicates fish use less than half of the lake bottom area, so yield-per-acre estimates, which are two times greater, might come closer to representing the yield from presently-utilized areas.

Angler Origin

An estimated 47,732 angler-days[8] were expended at Lake Tahoe during 1962. About one-fourth of these trips were made by local Tahoe-California anglers. In descending order, other significant areas of origin were the San Francisco Bay area (Region 3), central California (Region 2), Reno and Sparks, and the Los Angeles area (Region 5) (Table 6). Anglers from distant portions of California, Nevada, and

[8] The average angler-day for 1962 at Cave Rock was 4.65 hours for deepliners, 3.56 for topliners, and 2.28 for shore anglers.

TABLE 6

Angler Origin for All Fishing Methods in Lake Tahoe, 1962

Estimated Angler-Days

Angler origin *	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	All 1962	Percent of total
Region 1 California	0	0	0	12	0	30	32	19	3	0	0	0	96	0.2
Region 2 California	84	216	137	1,396	551	1,903	1,479	808	365	203	102	212	7,456	15.6
Region 3 California	0	52	64	538	292	2,663	2,549	1,704	566	236	91	251	9,006	18.9
Region 4 California	0	0	0	26	15	464	251	97	27	0	3	12	895	1.9
Region 5 California	0	0	0	70	61	1,373	1,431	1,402	526	90	2	80	5,035	10.5
Tahoe— California	445	426	534	2,858	1,282	2,262	1,336	522	384	460	278	1,447	12,234	25.6
Tahoe Nevada	62	58	67	169	92	461	314	83	128	183	22	181	1,820	3.8
Reno, Sparks, Nevada	216	180	220	769	862	1,577	1,431	583	522	166	84	559	7,169	15.0
Carson City, Nevada	83	0	29	228	157	597	270	266	151	62	54	172	2,069	4.3
Other areas— Nevada	0	0	0	155	22	504	239	207	17	11	0	10	1,165	2.4
Other states	0	0	0	0	58	263	253	123	34	53	3	0	787	1.6
Total angler-days	890	932	1,051	6,221	3,392	12,097	9,585	5,814	2,723	1,464	639	2,924	47,732	99.8

* See Figure 3.

other states fished mostly during spring and summer. Anglers living at moderate distances from Tahoe showed the same tendency but to a lesser degree. Local anglers were even less influenced by the seasons.

SUMMARY

The California and Nevada Departments of Fish and Game jointly conducted a creel census at Lake Tahoe from September 1960 through 1963. Purposes were to describe the fishery, to establish a baseline of existing conditions, to evaluate an experimental trout planting program, and to obtain biological data from angler-caught fish. This report describes estimates of total catch, total use, and angler origin, which were obtained from the 1962 census.

The estimated total use for 1962 was 144,147 angler-hours (47,732 angler-days). This amounts to 1.2 angler-hours per acre. Of the estimated 20,018 fish caught, 11,967 were lake trout, 4,125 were "wild" rainbow trout, and 3,365 were planted trout. Yield to the angler, excluding planted trout, was 0.34 pounds per acre.

The origin of Tahoe anglers varied seasonally. About one-fourth of all angling effort was by California anglers living within 5 miles of Lake Tahoe. Other significant areas of origin were the San Francisco Bay area, the Los Angeles area, central California, and the Reno-Sparks area.

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DETERMINATION OF SEXUAL MATURITY IN FEMALE STRIPED BASS (*ROCCUS SAXATILIS*)[1]

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Previously developed criteria were not satisfactory for determining the state of maturity of female striped bass caught in San Francisco and San Pablo bays, California, during the spring and summer of 1961. Observed females ranged from obviously immature to obviously mature with a complete intergradation of intermediate stages. The state of maturity of some at intermediate stages could not be determined. Some ovaries showed early stages of maturation a year or more before spawning. Most spawned-out fish remained recognizable throughout the spring.

The determination of sexual maturity in fish is essential to understanding various phases of their life history. This paper describes difficulties encountered in determining the sexual materity of female striped bass caught in San Francisco and San Pablo bays, California, in 1961. These difficulties were encountered while sampling angler-caught bass as part of a study of bass migrations.

In the spring of 1927, Scofield (1931) was unable to determine the maturity of female striped bass from this area. However, he was able to determine the maturity of bass caught throughout 1928 on the spawning grounds (roughly 30 or more miles upstream). He concluded that all females had a group of eggs averaging about 0.12 mm in diameter, with none in this group exceeding 0.29 mm. Some females had a second group of eggs which exceeded 0.29 mm in diameter. He concluded that these fish would spawn in the next spawning season. He found no females in the latter category between August and December.

More recently, Lewis (1962) examined female striped bass from the Albemarle Sound-Roanoke River system, North Carolina. He classified ova into three groups: (i) translucent ova between 0.03 and 0.23 mm in diameter; (ii) translucent ova between 0.16 and 0.30 mm in diameter in which the yolk had begun to form; and (iii) opaque ova 0.33 to approximately 1.00 mm in diameter. He found females falling into three categories—those with type 1 eggs only, those with type 1 and 2 eggs only, and those with type 1, 2, and 3 eggs. He concluded that fish with types 2 and/or 3 ova were maturing and would spawn in the next spawning season. He had samples from every month except June, and found ova developing slowly in the summer and fall, and rapidly as the spawning season approached.

METHODS

Angler-caught striped bass were examined on 8 days between April 8 and June 24 to determine sex ratios and state of maturity. A small

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sample of ovaries was also collected in late August and early September. Ovaries were collected from females whose state of maturity could not be judged from gross observations, and from a sample of obviously mature and immature females. Collected ovaries were preserved in 10 percent formalin. Sections of each ovary were examined with a dissecting scope, and 15 of each type egg described by Lewis were measured with an ocular micrometer at a magnification of 48x.

Lewis found no eggs between 0.30 and 0.33 mm in diameter, and this permitted an objective separation between type 2 and 3 eggs. In my study, intermediate-sized ova were found and some groups of developing ova had a mode in this range. Hence, a subjective judgment was made based on Lewis's visual criteria, and some ova as small as 0.25 mm were considered type 3.

RESULTS AND DISCUSSION

It was initially hoped that the state of maturity could be determined by gross examination, since collections were being made during the spawning season. However, it immediately became apparent there were all intergradations between ovaries showing no egg development and ovaries having greatly enlarged eggs and the green color typical of mature fish.

Egg measurements (Table 1) showed a group of fish ranging up to 23 inches fork length which had only type 1 eggs. These were obviously immature and agreed with Scofield's and Lewis's findings.

TABLE 1

Summary of Egg Development in Striped Bass Ovaries Collected in San Francisco and San Pablo Bays During 1961

Collection	Number of ovaries							
	Type 1 eggs only		Type 1 and 2 eggs		Type 1, 2, and 3 eggs		Spawned out	
	Range in length *	Number of fish	Range in length *	Number of fish	Range in length *	Number of fish	Range in length *	Number of fish
April 8 and 15	15–22	12	19–23	12	20–25	7	29	1
May 13	16–22	15	18–26	28	20–26	11	25–30	4
May 27	17–23	24	18–30	33	20–33	22	21–29	14
June 10	17	1	20–25	11	21–32	5	23–32	22
June 24	18–22	4	17–21	7		0	22–26	5
August 26 to September 10	18–21	6	20–27	9	22–29	5		

* Fork length to the nearest inch.

A second group of fish had both type 1 and 2 eggs. These ranged in size up to 30 inches fork length, but only four were over 24 inches. These fish made up a considerable portion of the catch throughout the spring, and the average diameter of type 2 eggs in these fish (Table 2) remained similar. Considering this, and Scofield's and Lewis's findings that maturing eggs grew from about 0.3 to 1.0 mm or larger over a period of several months before spawning, it is reasonable to conclude that these fish are at least a year away from maturation. Since substantial numbers of these fish were present in early April, some bass must develop type 2 eggs more than a year before spawning. This does not conflict with Scofield's findings, but it does not agree with Lewis's results. He apparently found no bass with only type 1 and 2 eggs in the winter or spring. Hence he considered fish with either type 2 or 3 ova to be mature.

TABLE 2

Distribution of Mean Diameters of Type 2 Ova From Female Striped Bass With Type I and 2 Ova

Mean diameter in mm	*April 8 and 16*	*May 13*	*May 27*	*June 10*	*June 24*	*Aug. 26–Sept. 10*
.150–.174				1		
.175–.199	4	4	4	3	4	4
.200–.224	6	18	19	16	5	5
.225–.249	1	8	11	8	3	
.250–.274		1	2			
.275–.299			2			

The mean size of type 3 eggs in individual fish had a wide range throughout the spring (Figure 1). On every sampling day through June 10, some bass with green ovaries were observed, although no egg samples were taken from these on two occasions. These ovaries were grossly similar to those typically found in the spawning area, and the ova were similar in size to Scofield's and Lewis's measurements of mature ova in the spring. These were obviously mature bass.

In addition, many bass had smaller type 3 eggs. In some cases, these grossly appeared to be the dominant egg type, while in others they were scattered and gave a flecked appearance to the ovary. It is not clear whether Scofield observed any ovaries of this type on the spawning grounds in 1928, but his description suggests that ovaries of this type led to his failure to determine age at maturity in San Francisco and San Pablo bays in 1927. Lewis apparently did not find ovaries similar to these, since he found no ovaries with type 3 eggs in which the largest eggs were smaller than about 0.65 mm in April and about 1.05 mm in May.

The bass found in late May and early June with type 3 ova averaging between 0.3 and 0.4 mm presumably are from the same group which had type 3 ova averaging about 0.4 mm late in the summer (Figure 1). These are similar to the developing ova Lewis found in late summer and presumably are the eggs which would be laid in the next spring. This is further evidence that some bass ova show recognizable development a year prior to spawning.

Bass with intermediate-size type 3 eggs dominating the gross appearance of the ovary in April, May, and early June may ripen and spawn late in the current spawning season. However, it seems improbable that bass with ovaries showing little enlargement, and only a scattering of type 3 eggs, would spawn in the current season. Further observations will clarify these points.

Spawned-out bass ranging in fork length from 21 inches up were observed throughout the spring (Table 1). Their ovaries were flaccid, had thickened walls, and some showed evidence of hemorrhaging. The majority had at least a few unspawned type 3 eggs; many of these appeared to be in the process of being resorbed. Almost all larger bass either had eggs definitely maturing in the current year or were spawned out, suggesting that spawned-out bass remained recognizable throughout the spring. Presumably some bass observed in the late summer had spawned the previous spring, but none had recognizable characteristics of spawned-out ovaries.

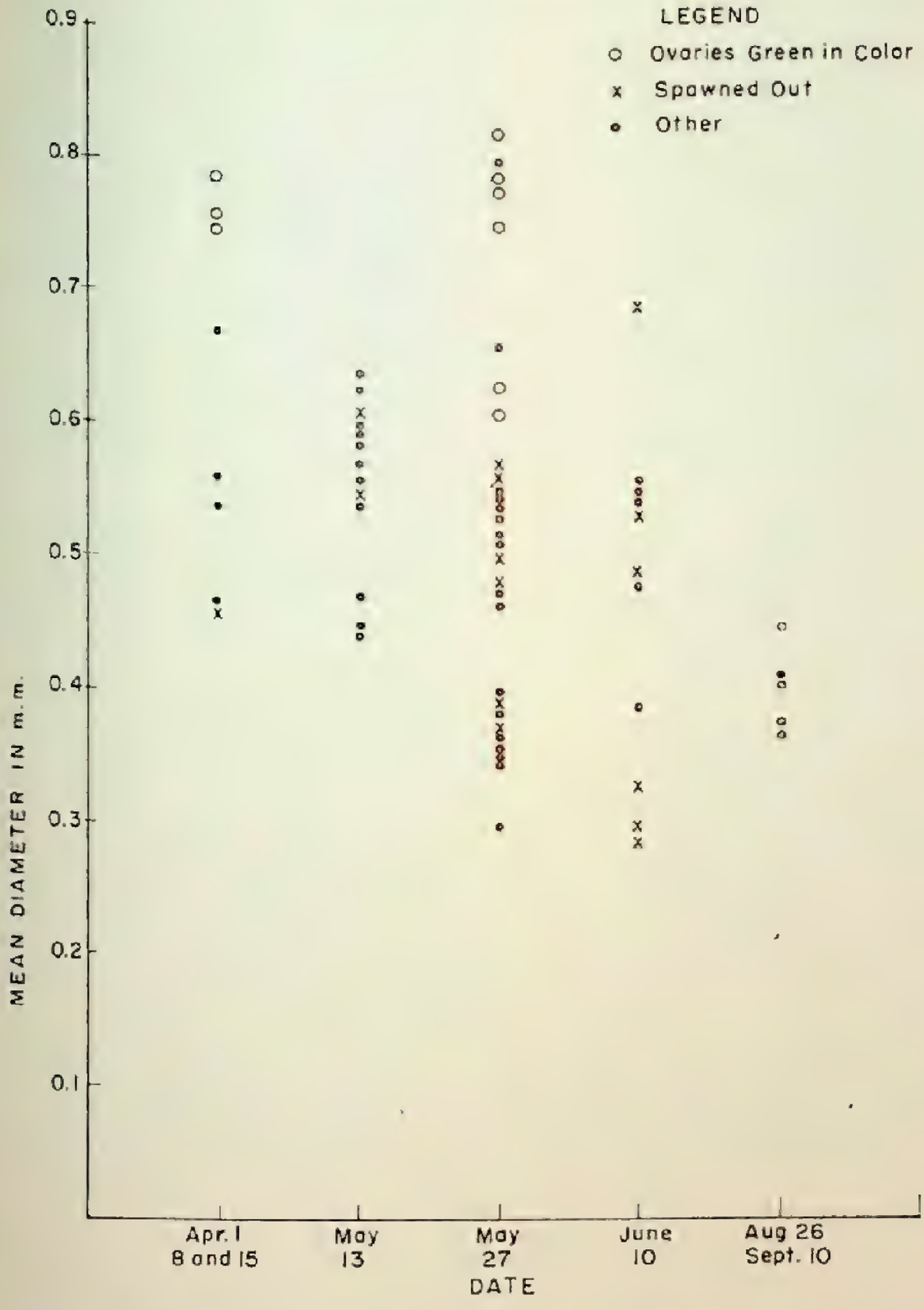

FIGURE 1. Mean diameters of type 3 ova from striped bass collected in San Francisco and San Pablo bays. *Figure drawn by Cliffa E. Corson.*

CONCLUSIONS

These observations indicate that the criterion Scofield used to determine the state of maturity of female striped bass in the spawning area in the Sacramento-San Joaquin Delta and the criteria Lewis used in Albemarle Sound-Roanoke River system in North Carolina are not satisfactory for determining the state of maturity of female striped bass in San Pablo and San Francisco bays during the spring. This results from some ova showing signs of developing a year or more before they ripen, and from the presence of bass having ova intermediate in development between these and the mature ova Scofield and Lewis found in the spring. Present knowledge is insufficient to determine the state of maturity of some bass with intermediate ova development.

Most spawned-out females remained recognizable through June, and none of a small sample taken in late summer was recognizable as being spawned out. Collections in the intervening period will be necessary to determine approximately how long spawned-out females remain recognizable.

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NOTES

OCCURRENCE OF LEAD POISONING IN A WILD PHEASANT *(PHASIANUS COLCHICUS)*

We believe this is the first report of lead poisoning of a wild pheasant in America, although two cases of lead poisoning on English game preserves have been reported (Calvert, 1876; Holland, 1882). These two reports gave no record of lead levels in tissue from the affected birds.

A dead male pheasant, found at the Grizzly Island Waterfowl Management Area on December 7, 1963, showed no signs of having been shot. For approximately 2 months prior, the area had supported extensive waterfowl shooting. This random deposition of shot provided an easily accessible lead source.

The specimen was extremely emaciated. Necropsy revealed an enlarged and distended proventriculus. The gall bladder was greatly enlarged. Due to the impacted proventriculus, there was no food in the gizzard or the intestinal tract. There were 29 lead shot or fragments thereof in the gizzard, along with a small amount of grit. The weight of this lead was 3.6 g. The keratinized lining of the gizzard was thickened and dark-green to black in color. A grayish discoloration of the intestines was observed. Basophillic stippling was not seen in the erythrocytes as the bird had been frozen, thus laking the red cells.

We used the dithizone method (Garner, 1957) in our extraction and quantitative tests to determine if lead were present in the bird's tissues, and found 42 ppm in the breast tissue and 168 ppm in the liver. These are far above normal values which are equal to or less than 1 ppm for either breast or liver tissue. Mensch (unpubl. ms) using experimental pheasants and force-feeding them lead shot produced plumbism. The values of lead he found were 50 and 143 ppm for breast and liver.

It is possible that when pheasant plumbism does occur in areas of heavy shooting, carcasses are not found because of the dense habitat preferred.

ACKNOWLEDGMENT

The authors express appreciation to personnel of the Division of Chemistry, California Department of Agriculture, for performing some of the chemical analyses. This study was supported by Federal Aid in Wildlife Restoration funds: California project W-52-R, "Wildlife Investigations Laboratory."

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—*Brian F. Hunter and Merton N. Rosen, Game Management Branch, California Department of Fish and Game, February 1965.*

TICK PARALYSIS IN CALIFORNIA DEER

In October 1962, two completely paralyzed blacktail deer (*Odocoileus hemionus columbianus*) were brought to the Department's Wildlife Investigation Laboratory from near West Point, Calaveras County. These animals, a female fawn approximately 5 months old and an adult doe, did not react to stimulus. Breathing was shallow and both had irregular heart beats. Because of the large number of ticks on each animal, the possibility of tick paralysis was considered. Thirty-nine engorged female ticks were removed from the fawn, and 59 from the doe. These parasites were concentrated on the head and neck regions. Within 2 hours the doe showed signs of recovery, and within 5 hours the animal was able to stand and walk, although somewhat unsteadily. Within the same period of time, the fawn made some recovery, but was not again observed until the following morning when it was found dead. It was evident however, that it had gotten to its feet and moved about. Examination showed that six engorged ticks had been missed. Autopsy of the fawn showed no pathology other than a thin-walled congenital cyst in the lung. The doe at this time appeared completely normal and remained so.

The 59 ticks on the doe were identified as *Dermacentor occidentalis*, the common coastal tick. Of the 45 engorged ticks removed from the fawn, 39 were *D. occidentalis* females and 6 were *Ixodes pacificus* females. In the area where these deer were found, several other deer were reportedly found dead. Several days later, a report was received that a paralyzed male fawn had been found near Georgetown, El Dorado County, and upon removal of numerous ticks appeared fully recovered the following day. I saw this deer about a week later and it appeared normal. Several of the ticks which had been removed were identified as *D. occidentalis* and *Ixodes pacificus*. These are the first reports of tick paralysis in deer in California. Although *Ixodes* were present on three of the four animals, it is assumed that these were not involved since *Ixodes* have not been known to produce paralysis in the United States.

In early November 1964, a paralyzed blacktail fawn found along the American River east of Sacramento in Sacramento County, was heavily parasitized by engorged *D. occidentalis*. The animal also suffered from exposure during a heavy storm prior to being found. Over 100 ticks were removed and the animal showed some recovery but did not survive.

In mid-November, a report was received that 13 deer had died on a ranch in the Sierra foothills of Fresno County. These were California mule deer (*O. h. californicus*) that had migrated from higher elevations to their winter range which included the ranch. A paralyzed adult male was found and was killed by the ranch foreman. This animal, and a 5- to 6-month-old fawn which was found dead, were autopsied. No pathology was found. Numerous ticks of all stages of engorgement infested both animals; at this time, tick paralysis was suspected. A survey of the area 1 week later produced a paralyzed fawn harboring numerous engorged ticks. Approximately 3 hours after removal of as many ticks as possible, the animal had become alert and more active. Several days previously two, 6-month-old domestic calves had been found on the ranch in a paralyzed condition. The day following re-

moval of ticks both calves were again active and feeding. On all of these animals the ticks were identified as *D. occidentalis*, with a few *Ixodes pacificus*.

The following month, in December, a report of dead and paralyzed deer was received from Shasta County. These deer were reported to have harbored numerous ticks. One animal was described as being paralyzed. None of the animals or ticks was examined, but tick paralysis was suspected. Although these are the first recognized cases, tick paralysis probably has occurred previously in deer in California. In several instances in past years, deer losses have occurred where no cause of death was found other than severe tick infestation. These losses have all occurred between October and December.

Tick paralysis is known to occur in man, domestic cattle, horses, sheep, dogs, and bison in the western states, Rocky Mountain states, and Canada, and is coincident with the distribution of the Rocky Mountain tick (*Dermacentor andersoni*). Gregson (1958) stated that, other than the bison, no large wild species is known to be susceptible; however, smaller wild mammals such as marmots (*Marmota* spp.), ground squirrels (*Citellus* spp.), and other rodents are.

The disease is caused by a toxin which is secreted by the female tick during its feeding. Paralysis occurs approximately 5 to 9 days after attachment by the ticks; it progressively ascends in the body of the animal, and causes death when the cranial nerves become involved causing the respiratory system to fail. The nature of this toxin is not well understood, but apparently it interferes with neuromuscular activity (Murnaghan, 1958). Tick removal results in rapid recovery unless paralysis has progressed too far.

Hughes and Philip (1958) produced tick paralysis in laboratory animals, and indicated that the hamster is the animal of choice for such studies. This gives a method for studying the disease and the ability of the ticks to produce paralysis.

Although tick paralysis occurs primarily in the Pacific Northwest, it is becoming more common in the eastern and southern states, affecting man and dogs in association with other species of ticks (*D. variabilis, Amblyoma americanum*, and *A. maculatur*) (Costa, 1952).

Tick paralysis has been previously reported in domestic animals in California and was caused by *D. occidentalis* (Parker, Brooks, and Marsh, 1929; Emminger, 1951). Coincident with the cases of deer paralysis, outbreaks of the disease have occurred in cattle and horses in several counties of California (E. Loomis, pers. commun.).

Although *Dermacentor andersoni* occurs in northeastern California and from there down the east side of the Sierras to Mono County, no cases of paralysis attributable to it have been recognized in domestic animals or wildlife. On the other hand, *D. occidentalis* is widely distributed in California, but cases of deer paralysis from it have been restricted to limited foci, and the involved animals have been found in a small area.

The seasonal incidence in California deer has been from October to December. This is because the adult *D. occidentalis* is active and feeding during these months, which contrasts with *D. andersoni* where the seasonal incidence of paralysis is predominant during spring and early summer when its feeding activity is highest.

The only treatment is to remove the ticks, either by hand or by chemical sprays. A rapid and dramatic recovery of the animal is diagnostic for the disease.

ACKNOWLEDGMENT

This study was supported by Federal Aid in Wildlife Restoration Project California W-52-R, "Wildlife Investigations Laboratory."

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—Oscar A. Brunetti, Game Management Branch, California Department of Fish and Game, March 1965.

FRESHWATER SILVER SALMON, *ONCORHYNCHUS KISUTCH* (WALBAUM)

The California Department of Fish and Game has successfully maintained a strain of silver salmon in fresh water for three generations. These fish have never migrated to salt water, completing their full life cycles in hatchery waters. All eggs used in the experiment came from fish which were spawned artifically.

The history of these fish began with eggs from 1955 brood year sea-run silver salmon. Mt. Shasta Hatchery received 60,636 of these eyed eggs from the Lewis River Station of the Washington Department of Fisheries on December 9, 1955. The eggs were hatched at Mt. Shasta Hatchery and held there until August 1956. They then were transferred to ponds at Darrah Springs Hatchery for rearing and planting. In April 1957, some of these yearlings at Darrah Springs Hatchery were believed large enough possibly to produce eggs if held in colder water. Two-hundred were sent to Mt. Shasta Hatchery for observation.

On January 17, 1958, two females of this group, now 24 months old, were spawned artifically, and yielded 1,340 green eggs. Of these, 927 survived to the eyed stage and started to hatch March 15, 1958. From these eggs, second-generation in fresh water, 300 fry survived and grew to an average length of 8 inches by the end of the first year. They were transferred to Crystal Lake Hatchery in June 1959.

No ripe females were noted in 1959.

In 1960, seven females were spawned on November 21. At this time, they were 32 months old, and averaged about 18 inches in length and 2 pounds in weight. They were spawned alive and yielded 2,013 green

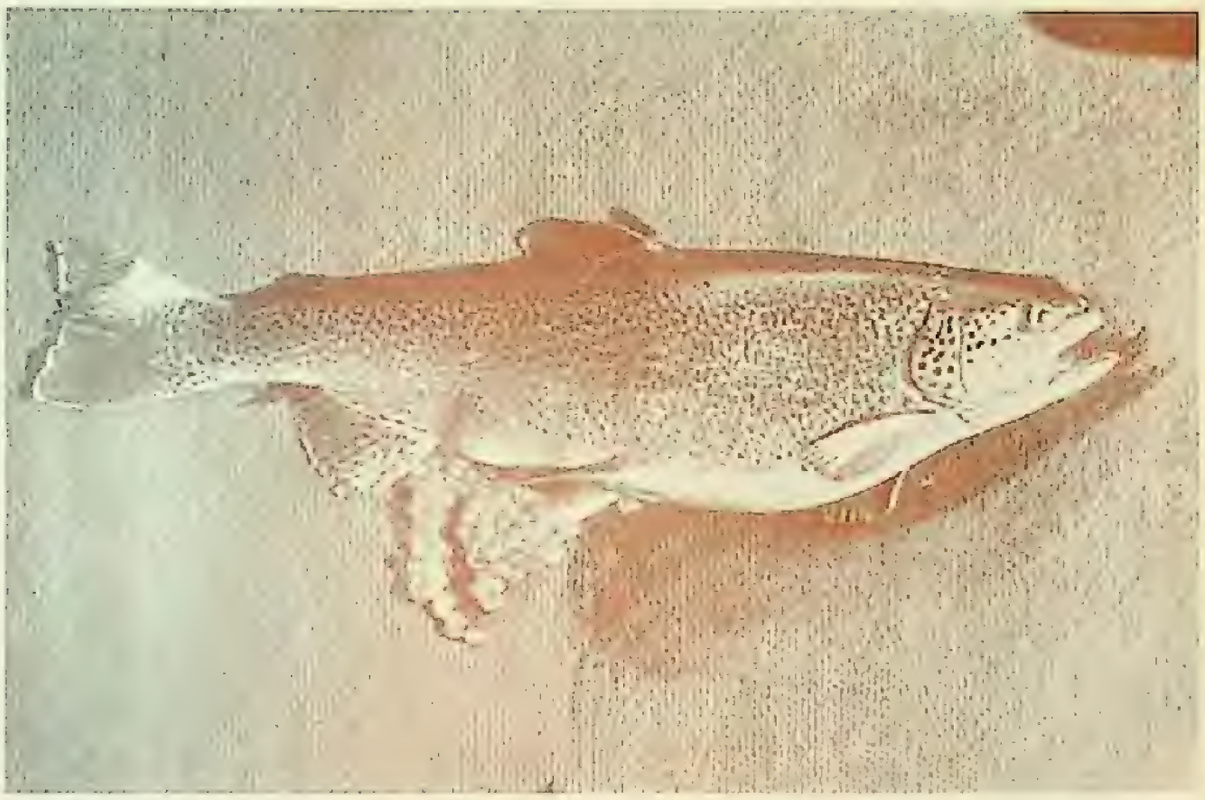

FIGURE 1. Three-year-old, third generation freshwater silver salmon female reared at Crystal Lake Hatchery. The eggs averaged three per linear inch. *Photograph by C. W. Woodhull, March 31, 1961.*

eggs, third-generation in fresh water. Only seven of these reached the eyed stage. The eggs averaged 11/32 inch in diameter (3 per linear inch). Their large size and an extremely delicate shell caused many to rupture as they were extruded through the small vent. A number of precociously ripe males died during November.

The next 59 females were killed and cut open to obtain the eggs. These fish produced 27,912 green eggs in five spawnings, November 29, and December 12, 19, and 27, 1960, and January 4, 1961. The eggs were hatched and produced 6,000 abnormally-large fry. The greatest loss occurred from the eyed egg stage to hatching time. During this critical period, the eggs were very soft and actually exploded or collapsed when touched with an egg-picking tube, but fungus was controlled effectively with daily flushes of malachite green.

Additional spawnings could have been made, but because of the poor quality of the eggs it was decided to keep the remaining 20 "green" females and 18 males under observation. These fish made no attempts to build redds in the pond gravel, nor did they exhibit any signs of migratory activity, such as jumping at the intake water supply. One by one the females became covered with fungus and died; they were autopsied and found to contain glassy, water-hardened eggs, many still attached to the ovaries.

A male and a female were the last of this group of spawners; the female (Figure 1) was at least 2 weeks overripe. Thus, the spawning period may be considered to have extended from November 21, 1960, until March 15, 1961.

Of the 6,000 fry produced from the spawnings in November and December 1960 and January 1961, 4,000 reached an average of 1 ounce each by October 1961. On March 24, 1962, 65 of the largest fish of this group, now yearlings, were transferred to Humboldt State College for further experimentation, but were lost when treated for ectoparasites with an excess of chemical. The remainder of the group were released in Baum Lake, adjacent to Crystal Lake Hatchery, when the hatchery was struck by an epizootic of the protozoan *Ceratomyxa shasta*.

The observations recorded here showed that: (i) silver salmon can be reared entirely in fresh water for several generations; (ii) such fish lose their natural spawning instinct; (iii) the eggs grow to a larger size than those from sea-run fish; and (iv) through a selective breeding program a freshwater strain could probably be developed for stocking in inland waters.

Delbert A. West, Region 1, Inland Fisheries, California Department of Fish and Game, February 1965.

EVIDENCE OF AMERICAN SHAD REPRODUCTION IN A LANDLOCKED ENVIRONMENT

The American shad, *Alosa sapidissima,* is an anadromous species hich does not normally complete its life cycle without spending 2 to 5 years at sea. Adult shad will take up residence in fresh water (Greeley, 1939), but I know of no previous accounts of successful spawning in landlocked environments.

Intensive gill-net sampling at Millerton Lake, Fresno/Madera counties, produced 26 American shad in 1963. These fish ranged from 6.3 to 14.6 inches fork length.

Striped bass, *Roccus saxatilis,* were transplanted from the Mendota Canal and the Tracy Pumping Plant to Millerton Lake several times between 1955 and 1957. Presumably, American shad fry were introduced with these plants, since they are abundant in those areas and none was observed previously in the lake. No fish have been introduced since that time from areas where American shad are present. Shad from these plants would have been ages VI through VIII in 1963.

Ages were determined for 18 of the 26 shad from their scales, and most were judged to be from age groups IV through VII, but two, 6.3 and 7.7 inches FL, were probably age II. If the scales were interpreted correctly (method of Borodin, 1924) 11 of the 18 fish examined were the result of lake propagation.

Cating (1953) attempted to use Borodin's method of determining American shad age without success. However, Cating's data indicate that my interpretation of Borodin's method would tend to overestimate shad ages. If this is so, an even higher percentage of shad captured in this study would have been from lake propagation.

ACKNOWLEDGMENT

This work was performed as part of Dingell-Johnson Project California F-18-R, "Experimental Management of Warmwater Reservoirs," supported by Federal Aid to Fish Restoration funds.

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—Charles E. von Geldern, Jr., Inland Fisheries Branch, California Department of Fish and Game, February, 1965.

A SECOND RECORD OF THE PELAGIC ARMORHEAD, *PENTACEROS RICHARDSONI* SMITH 1849, IN CALIFORNIA WATERS

On October 6, 1964, Mr. Louis Bernhardt, master of the trawler *Anna W* contacted the Department of Fish and Game's Eureka Laboratory requesting aid in identifying an unusual fish. It was a pelagic armorhead, the second specimen known from California waters (Figure 1).

The fish was recovered from a catch of pleuronectids, principally *Microstomus pacificus* (Lockington), northwest of Trinidad Head (lat. 41° 11′ N; long. 124° 21′ W) in 115 fathoms.

Pelagic armorheads are relative newcomers to the eastern Pacific. Specimens have been recorded from British Columbia (Clemens and Wilby, 1961), Oregon (Wagner and Bond, 1962), and California. Follett and Dempster (1963), who recorded the California occurrence, suggested the species had been transported east by the north Pacific current system from its center of abundance off southern Japan.

FIGURE 1. Pelagic armorhead, *Pentaceros richardsoni*, captured by Eureka trawler, *Anna W*, October 5, 1964. *Photograph by Dan Gotshall.*

The present specimen measured 305 mm TL (253 mm SL) with a head length of 187 mm. The dorsal fin had 14 spines and 8 rays while the anal fin had 4 spines and 7 rays. Seventy-four lateral line pores were also counted. The specimen has been added to the collection of the California Academy of Sciences, San Francisco.

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—*J. Gary Smith, Marine Resources Operations, California Department of Fish and Game, December 1964.*

LENGTH-WEIGHT RELATIONSHIP OF BLACK SKIPJACK TUNA, *EUTHYNNUS LINEATUS*

The black skipjack is a tuna restricted exclusively to the waters of the eastern Pacific Ocean. It is sold at fresh fish markets in several Latin American countries, but it is judged to be unsuitable for canning and is of little commercial importance.

Data on the biology of the black skipjack are rather meager. Lack of even the most basic information, except for the detailed systematic description by Godsil (1954), became evident to us when we undertook preparation of a synopsis of biological data (Calkins and Klawe, 1963).

We have prepared this report to add to one facet of the vital statistics of *E. lineatus*.

Incidental to work on the yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tuna the scientists of the Inter-American Tropical Tuna Commission collected specimens of *E. lineatus*. These were obtained either while participating in some of the Commission's scientific cruises, or from catches made by commercial tuna boats from waters off Baja California, Central America, and Ecuador. Since black skipjack are brought to the canneries only in exceedingly small numbers, and only as an undesirable admixture to the catches of yellowfin and skipjack tuna, they are scrupulously removed from canning lines and end among the rejects. One-hundred-and-nine specimens obtained in this manner were used in this study. They ranged from 365 to 667 mm total length, and in weight from 2 lbs. to 13 lbs. 13 oz.

The total length of each fish was measured to the nearest millimeter according to the procedure described by Marr and Schaefer (1949). Each fish was weighed to the nearest ounce. For purpose of our calculations, these weights were converted to pounds and decimal fractions.

Because of the rather small number of available specimens, no investigation was made of possible differences in the length-weight relationship between sexes or between areas. From our calculations, we derived the following relationship of the weight on length for *E. lineatus:*

$$Y = 3.0817X - 7.6155 \quad \text{(1)}$$

or

$$W = (2.4237 \times 10^{-8})L^{3.0817} \quad \text{(2)}$$

In (1), Y and X represent common logarithms of the weight in pounds and the length in millimeters respectively (Figure 1), and in (2), W and L represent the weight in pounds and the length in millimeters

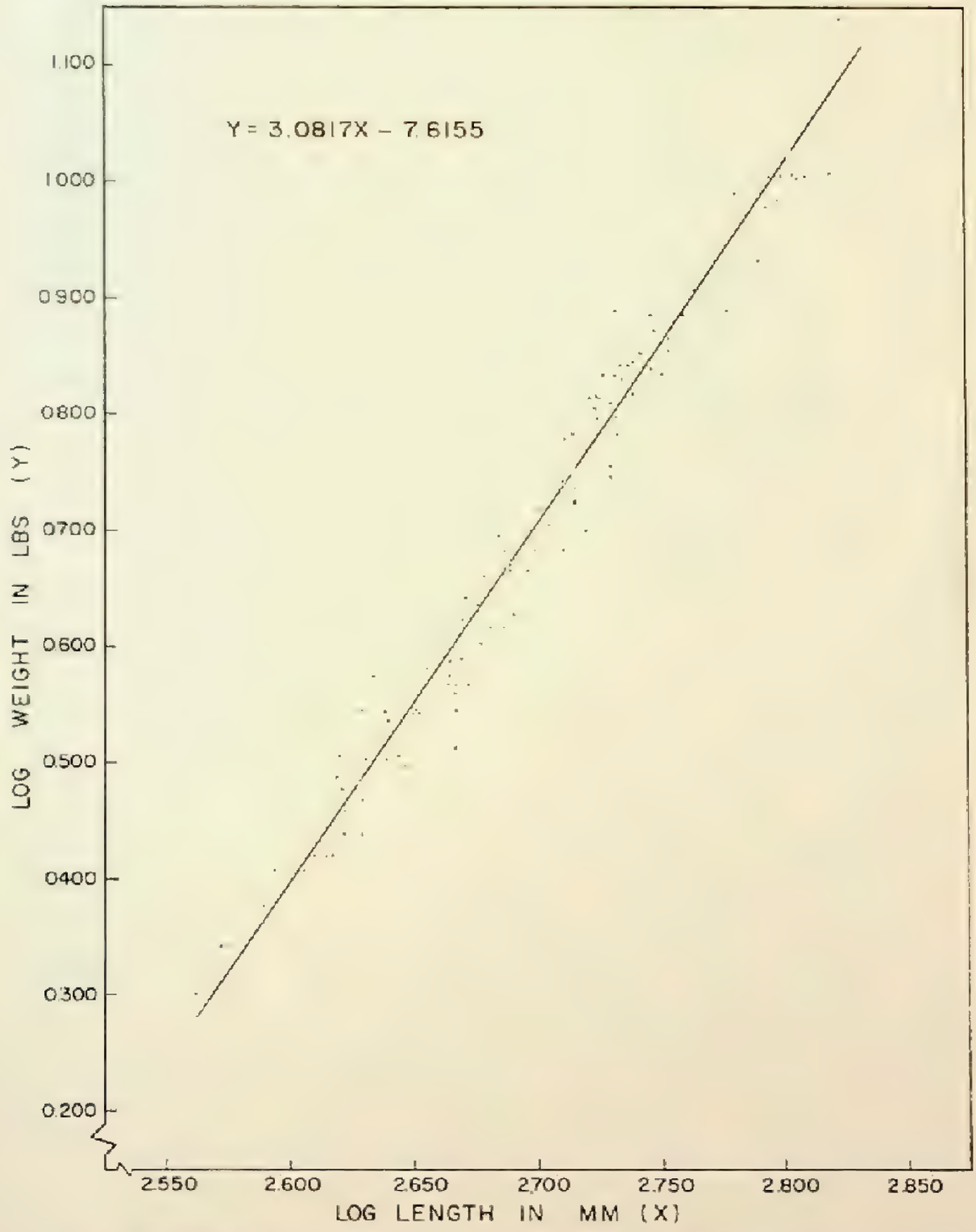

FIGURE 1. Linear regression of the logarithm of the weight on the logarithm of the length of the black skipjack tuna, *Euthynnus lineatus*.

respectively. The original data on which this study was based are available on request.

ACKNOWLEDGMENTS

We wish to express our appreciation to the many masters and crews of the commercial tuna boats who aided us in many ways in obtaining the material used in this study. The scientific personnel of the Commission's laboratories in La Jolla and Terminal Island helped in gathering samples as well as data. Among those who rendered such help, Miss Alice A. Williams must be singled out, and our sincere and special appreciation goes to her.

RESUMEN

La relación entre la longitud y el peso de 109 *barriletes negros, Euthynnus lineatus, cuyas longitudes y pesos variaron entre* 365 *y* 667 mm *y de* 2 lbs. *a* 13 lbs. 13 oz. (*libra de* 454 g) *respectivamente, se calculó en:*

$$Y = 3.0817X - 7.6155 \quad (1)$$

o bien

$$W = (2.4237 \times 10^{-8}) L^{3.0817} \quad (2)$$

donde Y representa el logaritmo del peso expresado en libras, X el logaritmo de la longitud total en milímetros, W representa el peso expresado en libras y L la longitud total en milímetros.

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—*Witold L. Klawe and Thomas P. Calkins, Inter-American Tropical Tuna Commission, La Jolla, February 1965.*

HEMOGLOBIN CONTENT OF THE BLOOD OF FIFTEEN SPECIES OF MARINE FISHES

The ability of the blood to carry oxygen depends on the concentration of the respiratory pigment present, and its nature. A knowledge of the amount of hemoglobin in the blood of fishes can be of considerable significance in understanding their ecological and physiological relationships.

Many of the analytical techniques commonly used for determining blood hemoglobin levels are not suitable for fish bloods (Anthony, 1961). Colloidal suspensions, unstable solutions, or inadequate standardizations are hazards frequently encountered in many of the analyses. As a consequence, some of the data available in the literature respecting hemoglobin levels in fish bloods may not be completely reliable.

The pyridine hemochromogen technique of Roets (1940) and Collier (1944) has been demonstrated to be a satisfactory analytical technique for determining hemoglobin concentrations in fish blood (Anthony, 1961; Klawe, Barrett, and Klawe, 1963). Recently, in the course of other studies on tunas, the blood of 15 species of marine fishes (mostly scombroids and billfishes) has been collected and analyzed for hemoglobin content by this technique (Table 1).

The fish sampled were collected from many parts of the Pacific Ocean in 1963 and 1964 by jig, troll, live-bait, purse-seine, or long-line techniques aboard commercial tuna clippers, tuna purse seiners, a Japanese exploratory long-line fishing vessel, and a sportfishing boat. Blood samples were taken by direct heart puncture, except for those from the northern anchovy (*Engraulis mordax*) which were taken from the cut caudal artery. Heparin solution, used routinely as the anticoagulant, was introduced into the syringe and the excess ejected. Blood samples from kelp bass (*Paralabrax clathratus*), yellowtail (*Seriola dorsalis*), Pacific bonito (*Sarda chiliensis*) and northern anchovy were held on ice and analyzed within a few hours after being taken. The rest of the blood samples were frozen. Prior to analysis, the frozen samples were thawed overnight in a refrigerator.

TABLE 1

Range, Mean, and Standard Error of the Mean of Blood Hemoglobin Levels in 15 Species of Marine Fishes

Species	*Common name*	*Number*	*gm Hb/100 ml*		
			Range	*Mean*	*S.E.*
Mackerel and Tunas					
Thunnus thynnus	bluefin tuna	10	18.7–21.0	19.8	0.28
Auxis rochei	frigate mackerel	10	16.5–22.8	19.2	0.57
Thunnus alalunga	albacore	11	15.3–19.3	17.2	0.36
Thunnus albacares	yellowfin tuna	8	12.5–19.8	16.8	0.86
Thunnus obesus	bigeye tuna	25	10.3–20.8	15.6	0.53
Sarda chiliensis	Pacific bonito	9	11.2–15.3	12.9	0.74
Acanthocybium solanderi	wahoo	9	5.9–16.5	10.4	1.2
Billfish and Swordfish					
Makaira nigricans	blue marlin	8	7.4–16.2	13.0	2.0
Tetrapturus angustirostris	shortbill spearfish	13	8.2–15.6	12.9	0.50
Tetrapturus audax	striped marlin	16	5.8–16.8	11.3	0.75
Xiphias gladius	swordfish	5	5.3–12.5	10.2	--
Other					
Engraulis mordax	northern anchovy	9	11.7–16.8	14.4	0.54
Coryphaena hippurus	dolphinfish	18	8.1–14.4	11.6	0.46
Seriola dorsalis	California yellowtail	5	4.0–14.7	8.3	-
Paralabrax clathratus	kelp bass	8	4.0–10.2	7.6	0.90

A pyridine hemochromogen method adapted from Roets (1940) and Collier (1944) was used for determining the amount of hemoglobin in the blood. To 6 ml of 0.1N NaOH in a colorimeter tube we added 0.02 ml of blood, measured with a Sahli pipet. The solution, in the tube, was boiled for 4 minutes in a water bath and then cooled. Two ml of pyridine (C_5H_5N) were added and the solution, after thorough mixing, was left to stand for 30 minutes in the dark. (This latter was a precautionary measure, but it is not a strictly essential part of the procedure. Analyses of solutions left standing for 8 minutes in direct

sunlight showed no significant differences in colorimeter readings from those held in subdued light.) Five to 10 mg of sodium hydrosulfite were added and the solution, after mixing, was read in a Bausch and Lomb Spectronic 20 Colorimeter at 545μμ.

Hemoglobin concentrations (g/100 ml blood) of the various bloods were determined from a Beer's law plot of a series of dilutions of Hyland Whole Blood Hemoglobin Standard (Hyland Laboratories, Los Angeles 39, California) treated by the method described above. A new determination of the Beer's curve was made for each day's analyses.

ACKNOWLEDGMENTS

We thank the Masters and crews of the tuna fishing vessels *Julia B.*, *Santa Anita*, and *San Juan*, the sportfishing vessel *Seaforth II*, and the Japanese R. V. *Shoyo Maru* for the many courtesies and facilities extended during the collection of the bloods. J. Barandiarán, E. L. Díaz, E. D. Forsbergh, W. L. Klawe, and R. Jordán took blood samples for this study. Mr. Klawe also provided advice and criticism during the preparation of the manuscript.

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—*Izadore Barrett and Alice A. Williams, Inter-American Tropical Tuna Commission, c/o Scripps Institution of Oceanography, La Jolla, California, March 1965.*

UNUSUAL SPONGE FOUND OFF NORTHERN CALIFORNIA COAST

On July 1, 1964, the trawler *Mary Ann* entangled 10 unusual sponges, *Mycale bellabellensis* (Figure 1), while trawling for sole northwest of Cape Mendocino (lat. 40° 34′ N, long. 124° 35′ W) in 70 to 80 fathoms. The skipper, Russ Wilson, donated them to me for identification. The 10 sponges ranged from 18 to 24 inches high and 10 to 14 inches in diameter.

Local authorities were unable to name these sponges, so one was sent to the California Academy of Sciences where Allyn G. Smith identified it. Several were also donated to Humboldt State College.

The type specimen was discovered by Lambe (1905) off the west coast of Canada. Reportedly, two have been found off Monterey, California : one was entangled by a fishing line in 27 fathoms, and another was taken from 436 fathoms (DeLaubenfels, 1932).

FIGURE 1. Side view of *Mycale bellabellensis* taken northwest of Cape Mendocino. *Photograph by Daniel W. Gotshall, August 1964.*

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—Hideto Kim Ujita, Marine Resources Operations, California Department of Fish and Game, February 1965.

SOUTHERN RANGE EXTENSIONS FOR CHUM AND SILVER SALMON

On November 9, 1955, a chum salmon, *Oncorhynchus keta* (Walbaum), was caught by the purse seiner *Saint Louis* in 20 fathoms of water off Del Mar, California (lat. 32° 57′ N., long. 117° 25′ W.). The fish was estimated to be 22 inches long. Positive identification by John E. Fitch, California Department of Fish and Game, was based on ring formation and shape of its otoliths (sagittae). This recovery is approximately 350 miles south of the San Lorenzo River, the previous southern record (Scofield, 1916).

A 14-pound, dressed weight, silver salmon, *O. kisutch* (Walbaum), was caught August 20, 1963, in 5 fathoms of water off San Jacinto Point Chamalu Bay, Baja California (lat. 30° 50′ N., long. 116° 11′ W.). The water temperature was 67° F. Ivan Goyette and Charles McMullen, owners of the fishing boat *Spindrift*, captured and saved the specimen for identification. Byers (1942) reported a salmon, supposedly a silver, from this approximate location August 4, 1942. The previous confirmed southern record was the Coronado Islands (lat. 32° 24′ N., long. 117° 14′ W.) (Scofield, 1937).

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—J. D. Messersmith, Marine Resources Operations, California Department of Fish and Game, March 1965.

NEW SOUTHERN RECORD FOR THE SILVERGRAY ROCKFISH, *SEBASTODES BREVISPINIS* (BEAN)

On March 15, 1965, a 2-pound, 12-ounce silvergray rockfish, 486 mm TL (450 mm SL) was taken by Arnold Cook, skipper of the sportfishing boat *America*, operating out of Pierpoint Landing, Long Beach, California. The specimen was caught by hook and line 4½ miles north of Santa Barbara Island (lat. 33°33.5′ N., long. 119°04.0′ W.) in 122 fathoms of water. Other species caught at this locality and depth included bocaccio (*Sebastodes paucispinis*), chilipepper (*S. goodei*), speckled rockfish (*S. ovalis*), and cow rockfish (*S. levis*).

The silvergray rockfish was previously recorded from the Bering Sea to Point Sur, California (Phillips, 1957). This capture extends the southern range 220 miles.

Silvergray rockfish are not rare in the northeastern Pacific Ocean. Alverson, Pruter, and Ronholt (1964), in their analysis of exploratory trawling data, found *S. brevispinis* important in rockfish catches from the 50-99 fathom depth interval, comprising 17 percent in the Oregon-Washington region, and 22 percent in the British Columbia-Southeastern Alaska region.

Silvergray rockfish are frequently confused with bocaccio. They differ from bocaccio primarily in color (dark gray above, silvergray on sides to an abrupt white below), in having maxillaries which do not reach the posterior portion of the orbit, and in having only seven anal fin rays. The bocaccio is light olive-brown above grading to pink below, and has an anal ray count of 9 to 10; its maxillary reaches to or beyond the rear border of the eye. If similar sized fish of both species are observed, the larger scales and larger eyes of the silvergray rockfish are immediately apparent.

The Santa Barbara Island specimen has been deposited in the fish collections of the Los Angeles County Museum (LACM 8610).

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—*Alec R. Strachan, Marine Resources Operations, California Department of Fish and Game, March 1965.*

BOOK REVIEWS

Scarcity and Growth: The Economics of Natural Resource Availability

By Harold J. Barnett and Chandler Morse; The Johns Hopkins Press, Baltimore, Md., 1963; xv + 288 p., illus., $5.50.

This book will shock many scientists and conservationists, as it questions the validity of concepts and principles generally accepted. It might be termed the antithesis of Secretary Udall's recent book entitled *The Quiet Crisis*. The study was conducted under the auspices of Resources For the Future, Inc., who have made numerous analyses of contemporary conservation problems.

Authors Barnett and Morse, two economics professors, have undertaken an analysis of natural resource scarcity in relation to growth. Resembling a textbook, it is well organized and documented. Some sections are difficult to understand and require close concentration.

Part I, comprising several chapters, describes the doctrine of increasing resource scarcity, as suscribed to by Malthus, Ricardo, and other more contemporary leaders in the Conservation Movement. Part II looks at population growth and increasing scarcity within the framework of unchanging socio-technical conditions. Part III introduces the possibility of social and technical changes, and Part IV summarizes and qualifies the entire analysis.

In brief, the authors conclude that population growth, resulting in natural resource scarcities, does not necessarily bring about increased costs and an economic decline. They believe that the process of growth generates antidotes to a general resource scarcity. They justify this hypothesis by analyzing the effect of growth upon United States resources, namely, agriculture, forests, minerals, and fisheries.

The dissertation, though scholarly, will not be too convincing to many biologists. It expresses the view that countries should utilize to the fullest extent possible, without waste, their natural resources with little concern for the future. This is based upon an improved technology being capable of meeting the changing needs of future society. It might be termed a cold-blooded economic analysis in which the question at issue is, whether in the face of scarcity, the cost reducing forces can keep up with or ahead of those that tend to increase costs.

Some recognition, although slight, is given to the importance of aesthetics and maintenance of quality in our environment.

In summary, it is evident that there is a wide divergence in views between economist and biologist when it comes to predicting our future, as related to population growth and resource needs. Wise resource use requires constant re-evaluation as new sources, substitutes and technologies become known. However, it seems irrational and an act of blind faith to follow the concept that adequate substitutes will become available as shortages occur. A more reasonable philosophy would emphasize frequent reassessment as our knowledge advances and conditions change.

It is a thought-provoking book, which should be read and discussed by everyone who considers himself a serious student of conservation.—*Willis A. Evans.*

Redwood Empire Wildflower Jewels

By Dorothy King Young; Naturegraph Publishers, Healdsburg, Calif., 1964; 80 p., 135 color illustrations, $4.50 cloth, $2.95 paper.

There are people who enjoy flowers but do not know the name of a particular flower, whether it is common or rare, and do not wish to peruse and study technical books to obtain this information. To these people, this book is primarily directed.

The author readily admits that her book does not cover all the wildflowers of this coastal region of northwestern California and southwestern Oregon, but is actually just a sample of a few of the flowers that may be observed in the redwood area. Having spent most of my life in this area and completing my plant taxonomy classes in colleges in Sonoma and Humboldt Counties, I feel qualified to state that the author has chosen her illustrations well. She has shown many of the common flowers along with some of the very rare specimens. She has revealed the vast number of families of flowers involved and has left the reader with the full knowledge that there is more to be seen in the Redwood Empire than could be printed in one small book.

I did feel, although the book is printed on good paper, that the quality of the reproductions of photographs suffered somewhere along the line. At least two pictures were printed upside down (Nos. 25 and 95), and some were slightly out of focus. This does not impair the usefulness of the book to any great extent, however.

The size of the book (5½ x 8½ inches) is a real asset. It can be conveniently carried in the glove compartment of a car or in a ladies handbag so that it can be a readily-available reference source.

To any person visiting or living in the redwood region, or to other persons interested in wildflowers or botany in general, *Redwood Empire Wildflower Jewels* would be an informative and enjoyable asset.—*Dick Laursen.*

Bowhunting for Deer

By H. R. "Dutch" Wambold, The Stackpole Co., Harrisburg, Penn., 1964; 160 p., illustrated; $5.95.

In the preface, Fred Bear of the Bear Archery Co., explained that he was "delighted to learn that the author has explained many of the bowhunter's problems in great detail. His research must have been timeless."

This statement was intriguing. Many of the recent books dealing with bowhunting discuss equipment, training for the hunt, tackle making, hunting lore, and general information. "Dutch" Wambold rehashes somewhat the existing information about these things, but has also engaged in some personal research that lifts this book above others in the field. It is far above average in interest and in *new* information.

Mr. Wambold is a bowhunter of long experience, and it is obvious in his first paragraph.

The whitetail deer is the target of discussion, but like the man said, "Don't care if the tail is black, white or mule — its all deer to me."—*Parke H. Young.*

Conservation—In the People's Hands

By AASA Commission on Conservation; American Association of School Administrators, Wash., D.C., 1964; ix + 330 p., illustrated; $6.

In 1962 a special Commission of governmental experts was appointed by the American Association of School Administrators to prepare a guide in conservation study, suitable for general use throughout the nation's schools. They recognized the importance of education in bringing about wise use of the country's natural resources.

As a result of their efforts, this is one of the better general conservation texts available. All major fields such as soil, water, air, forests, fisheries, and wildlife are covered, with specific examples of problems and their solution drawn from all parts of the country. Emphasis is placed upon positive steps that can be taken toward effective use of our natural resources, and especially to the contributions which schools can make.

The coverage of soils, agriculture, and forests were especially strong while those sections dealing with fisheries and wildlife were correspondingly weak. Despite this fact, it provides a worthwhile reading experience and reference for all fish and game personnel and others whose duty it is to educate the public on the subject of conservation.—*Willis A. Evans.*

Abyss: The Deep Sea and the Creatures That Live in It

By C. P. Idyll; Thomas Y. Crowell Co., New York, 1964; xviii + 396 p. illustrated; $6.95.

Abyss is one of the most interesting and easy-to-read books on the subject that has been published in recent years. Although it is unquestionably aimed at the non-scientist, it is well enough put together that it would even help to refresh the memory of an expert in the field of deep-sea biology, should he care to take some time to thumb through the volume.

Most phases of deep-sea biology are covered in this account, although sometimes too briefly to sate one's appetite. Actually, a fast reader could complete the entire volume in much less time than is required for a modern research vessel to make a single exploratory haul with a dredge in some of the deepest trenches in the Pacific—but then, few books are published which couldn't be read in that amount of time.

An initial 70 pages are devoted to explaining the abyssal environment and its circulation, and then the various phyla of deep-sea creatures are discussed. A final seven chapters cover such diverse subjects as living light, sea monsters, uses of the sea, the future of oceanography, etc.

Each chapter which covers a phylum of animals is introduced by a general discussion of the group—its requirements, its role in the ocean, its adaptations or specializations, its more peculiar members, etc. This is followed (usually) by a series of specific examples wherein the lives and loves of some of the more interesting critters of the group are "brought to light."

Although the list of specialists who reviewed various sections of the book is imposing, a few of the statements show too heavy a reliance on published works which are no longer (or never were) entirely reliable. A few items which I believe should have been questioned (even though some have long been passed from authority to authority as the unblemished truth) are: the statement that *Phronima* eats the colonies off a *Pyrosoma* and lives inside the transparent shell (pages 84, 86); the mention of a sea cucumber fishery off California (page 111); the "logic" given as to why male lobsters attain larger sizes than females (page 120); the use of the term "siphon" when discussing the "funnel" of cephalopods; the statement that "a big lanternfish is only 6 inches long" (page 213); and the theory that *Vampiroteuthis* seldom rises above the 3,000 foot depth (page 251). And there are others!

Regardless, this is still one of the most interestingly-written books on the *Abyss* that I have had the pleasure of reading.—*John E. Fitch.*

Advances in Marine Biology, Vol. 2

Edited by F. S. Russell: Academic Press, Inc., (London) Ltd., 1964: x + 274 p., illustrated; $9.50.

This is volume 2 in a continuing series which presents review articles of recent developments in marine biology. As in volume 1, numerous topics are reviewed.

In "The Artificial Propagation of Marine Fish," J. E. Shelbourne traces the historical rise and fall of marine fish hatcheries. He reports on recent experiments of rearing plaice (*Pleuronectes platessa*) in tanks at the Fisheries Laboratory, Lowestoft, England. Now that techniques for rearing plaice through metamorphosis have been established, plans have been laid to start working with summer-spawning flatfish. In conclusion, Mr. Shelbourne discusses some aspects of marine fish farming. This article can not guarantee success in rearing marine fish, but the equipment and techniques described will certainly simplify the task for anyone venturing into this field.

"The Blood Groups of Marine Animals" by John E. Cushing, reviews the development of this new tool in marine research. This is an introductory article into the field of blood grouping of marine animals. It also reviews studies made on animals from all over the world, and concludes with a brief description of techniques for collecting, preserving, and analyzing blood samples.

"The Present Status of Some Aspects of Marine Microbiology" by Robina B. Scholes and J. M. Shewan, is a review of our somewhat scarce knowledge in the field of marine microbiology. The authors consider microbiology to be the Cinderella of the marine sciences, although they note increased activities by the United States and Russia. They refer rather often to the works of ZoBell and Kriss, but in an addendum, they state that two recent papers by Sorokin have shown that Kriss used non-sterile Nansen-bottles, so both the qualitative and quantitative data of his book are open to serious doubt.

"Methods of Sampling the Benthos" by N. A. Holme, provides a good review of techniques for sampling both epifauna and infauna, the equipment available for these collections and how it works at sea, and finally how the sample is processed after collection. There are also short sections on "estimation of standing crop" and the "statistics" involved with such estimations. He also points out the need for improvements in sampling gear and development of semi-automatic sieving and washing equipment.

These are intended to be brief review articles, and, as such, they do not provide the details of the operations. To offset this, each paper has a rather extensive list of references which will allow interested parties to pursue the subject to a much greater degree.—*E. A. Best.*

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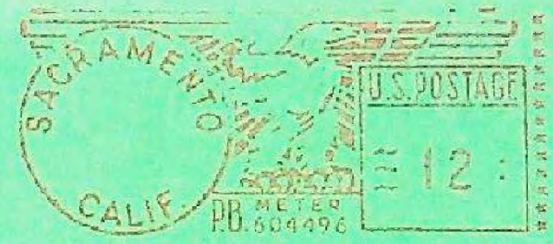

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